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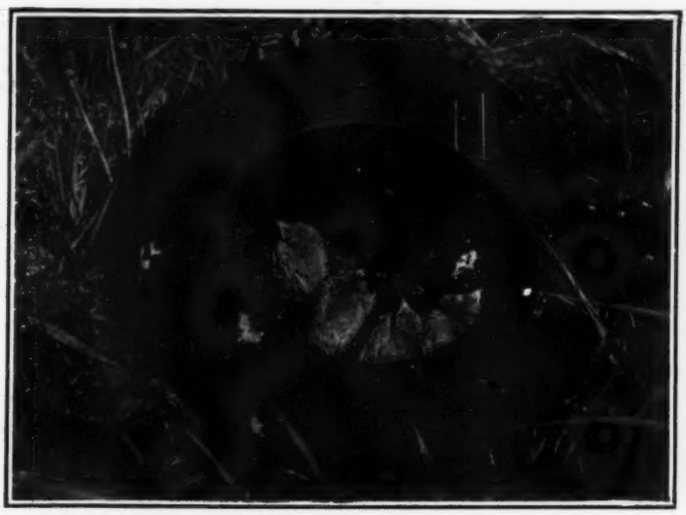
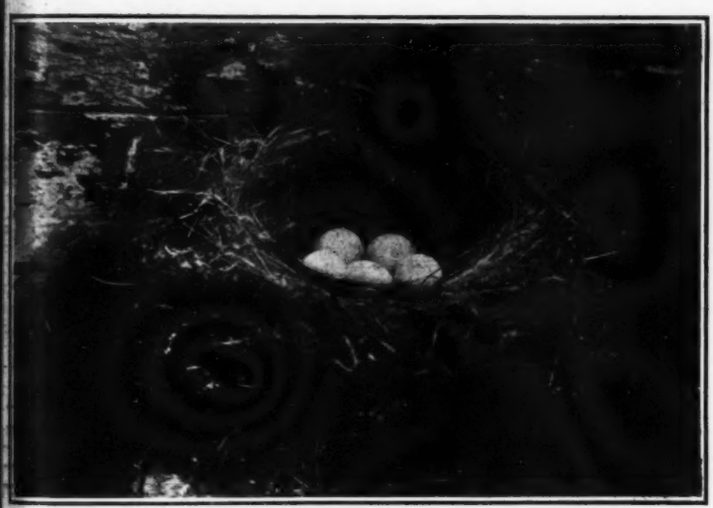
THE WOOD PEWEE'S HOME.



A FAMILY OF YOUNG PHOEBES COMPELLED TO POSE AGAINST THEIR WILL.



A FEATHERED NEIGHBOR'S HOME. THE PHOEBE'S NEST.

ALERT FOR DANGER. THE LEAST FLYCATCHER INCUBATING.

THE LEAST FLYCATCHER'S HOUSEHOLD CARES.

BABES IN THEIR NEST. FAMILY OF YOUNG LEAST FLYCATCHERS.

OUR AMERICAN FLYCATCHERS.

OUR AMERICAN FLYCATCHERS

SOME FEATHERED BENEFACTORS.

BY B. S. BOWDISH.

Of our "little brothers of the air," one of the best-known families is that of the flycatchers. One of the best known; yet how comparatively little does the average mortal know of the real economy of our common birds, even in this enlightened era of progress. In spite of the educational influence of the reports of the United States Department of Agriculture, and the humanizing effect of æsthetic and ennobling teachings, there are found in the country to-day people who would "shoot every robin in the State" because the birds have helped themselves to a few cherries. We have legislators who will work hard to pass a law, against popular opinion, making a game bird of the gentle, beautiful and economically valuable little mourning dove and opening the season on it before the bird's breeding duties are over for the summer, merely because a few constituents will have a vacation at that time and crave the pleasure of destroying some of the life that makes the world glad and beautiful; there are others who attempt to take all protection off the kingfisher, that merry sport whose presence gladdens the stream and millpond, and whose depredations are confined to "fry" too small to satisfy even the schoolboy; there are people who would shoot any hawk on sight, because some hawks have taken chickens, unmindful of the inestimable benefit that the family is to mankind—people who still believe that swallows hibernate in the mud for the winter, and that owls and whippoorwills are uncanny and portend evil or death; and these people are not the people who live in the city and see little of birds, but those to whom, in their country homes, the common birds should be as familiar as chickens. We must be too charitable to charge all of this to unkind hearts; it must be due to the only other alternative, ignorance.

INSPECTING HER TREASURES. LEAST FLYCATCHER AT NEST.

Flycatchers derive their name from the fact that a large part of their food consists of insects taken on the wing. These insects range through a wide variety of species, of which some are beneficial to man, but the number of pestiferous insects destroyed by the birds of this family will amply atone for any evil they may unwittingly do. Among the well-known members of the family are the crested flycatcher, kingbird, phœbe, wood pewee, and least flycatcher. Occasionally charges are made that the members of this group feed on the occupants of the beehives. This is sometimes true, but examinations of stomachs taken in different localities prove that on an average few honey bees are taken. Some few beneficial insects such as dragonflies are destroyed, but the great bulk of the food of these birds consists of pests such as flies, mosquitoes, gnats, and moths. They are not song birds, in fact the notes of the crested flycatcher are decidedly unmusical and quite weird. None of this group are brilliant of color, though neat and tasty in dress. Nevertheless, the flycatchers are bright, interesting birds and valuable to man.

The one which is undoubtedly the popular favorite is the phœbe. Before the country was settled this bird built its beautiful mossy nest in some niche of rock on the face of a cliff or embankment where the rocks above overhung and sheltered it. Some few of them still nest in that manner, but by far the greater part have deserted nature's provision for the artificial shelters of man's erection. About the eaves of the sugar camps and choppers' shanties in the woods, on the iron girders of bridges great and small, on the beams of the cowshed or barn, or even about the house porches, they find sites that seem to suit them. Often they are allowed to remain even on the porches, and they are usually welcomed elsewhere.

The phœbe is one of the very early birds whose return to its northern summer home is heralded as an announcement that spring has come again. It is not long after the arrival ere the site is chosen and the nest commenced. The birds have an attachment for one site, and where possible will use it year after year. If the old nest has remained over winter a new one will sometimes be built in it, rarely the old one is remodeled or torn down to be replaced; more often the new nest is built as near as possible to the old one. Two sites about a building may be used alternately year after year. It has been recorded that in one instance a phœbe became confused by a similarity in a number of available sites close together and constructed several nests simultaneously. If true, this bird was no more a fair sample of phœbe matron than is the inexperienced young housewife, whose troubles are always legion, a typical example of the average housekeeper. As a general thing, a phœbe building its nest knows what it wants and is businesslike. There is one record of a phœbe's nest swung on a wire, enough material being woven in below the wire to maintain a stable balance. Here was an example of a bird mechanical engineer.

On April 22 a nest was completed and held one egg. On the 29th there was a complete laying of five eggs. I photographed four of the five young on May 24 by placing them in my hat. On the 30th these birds were still sitting on the edge of the nest, but when approached they flew quite well. It is probable that the egg laying was completed April 26, and allowing about eleven days for incubation, the young must have made their debut into the world about May 7. According to this the young birds were twenty-three days in the nest, which is quite a little longer than the average period for most small birds.

Notwithstanding the charge against the kingbird of bee eating, he is rather a favorite with the country dweller. He is a bold, dashing fellow, no more afraid to chase crow or hawk from the neighborhood of his home than to rout a bird of his size; always busy, and an affectionate, attentive parent. These things probably count in his favor, even with the casual observer. The kingbird is much later in arrival and nesting than the phœbe, little if any earlier than the wood pewee. He usually takes no pains to conceal his nest; one of the favorite sites is an apple tree, and he prefers an open, scraggly, poorly-foliaged tree, where he is apt to place his nest well toward the top and out in an open point of vantage, whence there is a free outlook. Three or four is the size of the family that he attempts to raise, and their bill of fare is a varied one, consisting of moths and butterflies, dragonflies, beetles, house, dog, and horse flies, and many others, most of which, true to his family, he captures on the wing.

The least flycatcher is almost as much domesticated as the phœbe, making its summer abode usually, by choice, in the orchards and apple trees close about human habitations. It is a bird whose every movement betokens energy. Even when resting on a twig its tail will jerk and its head twitch this way and that, seemingly of their own volition; the note is abrupt, impatient, businesslike. The least flycatcher does not ornament the exterior of its nest with bits of lichen from the bark of trees as does the wood pewee, nor does it build so flat and inconspicuous a nest, but he soft gray material that forms the bulk of it blends well with the color of the limb on which it is built, and the position is chosen with a view to inconspicuousness, so that it is by no means an easy thing to locate a nest. The bird has a fondness for soft downy feathers, some of which are usually found in the structure or lining of the nest.

Once on June 1st I located a nest on the limb of a chestnut tree, about twenty feet from the ground. At this date no eggs had been laid, but on the 8th the nest contained four beautiful little cream-colored, unspotted eggs, and a photograph was secured, but no effort made to obtain a picture of the bird on the nest. On another June day, the 13th, I secured without difficulty photographs of a least flycatcher feeding young some five or six days old, in a nest about twelve feet from the ground in an apple tree. These two records about represent the average nesting date. The latter one most nearly represents the average height of the nest from the ground.

In another year I found a nest on June 24, saddled on a limb some twelve feet from the ground in an apple orchard. The nest was empty, and the limb it was on formed the only bottom to it. Passing the tree on July 1 I was surprised to find that the nest had been added to and contained four eggs, on which the bird was sitting. Three blue feathers from a bluebird had been stuck into the rim of the nest. I set the camera and extended the long tube and waited for some time for the bird to return, but she did not like the look of the camera and refused to come onto the nest while it was there, so it was removed. July 4 it rained until about 2 P. M. At 3 P. M. I got the camera set, and after a patient watch I secured a photograph of the bird beside the nest and another of her in the nest—standing, however, not seated. It was about 5 P. M. when the first photograph was secured, and the second was not obtained until about 6, rather a weak light for snap-shot work under foliage.

On July 7 I tried this bird again. Incubation was advancing in the eggs and the mother was becoming braver, also she was getting used to a camera. I secured four photographs of her sitting on this occasion. She had now only three eggs left, boys or some other vermin having robbed her of one. On the 14th I secured three more photographs. The bird had then only two eggs left. On the 22d the nest had disappeared, and after some search was found on the ground under the tree—a sad reward for the bravery and patience of the little sitter. This nest must have been the second attempt of this pair of birds for the season, it being at least a month later than the usual time.

On June 22 I located an unfinished nest of the wood pewee, and on July 4 photographed this nest and the two eggs it contained. Again on June 28 I photographed a nest and three eggs which were well advanced in incubation. On these occasions time was too short to allow of attempt at securing photographs of the birds, which however could probably be readily accomplished with sufficient time. Some years ago, when I used to find a number of nests of this species each year and examined a great many of them, June 15 was the average date that I set for the completion of the laying.

The sweet and pensive notes of these birds are more associated with late summer than with the breeding season, and they seem to suggest half sad relief in duties well performed. On occasion however there is nothing pensive about the bird, as it darts at some feathered intruder that has ventured too near its nest, and with graceful downward swoop gives a sharp snap of its wings just above the other's head ere rising again to a perch. The wood pewee does not confine itself to orchards for nesting sites by any means, though there is scarcely a suitable orchard without its pair of birds; they are equally

partial to open beech and maple woods. I knew of an instance where after a pair of these birds had built a nest and laid three eggs they were robbed of the eggs.

The birds removed most of the nest material to another tree only a few feet distant, constructing another nest in which they laid two eggs. Here again they were disturbed, and they removed the bulk of this nest, as before, constructing a new one some forty rods from the last site, in a tree by the roadside and outside the orchard. They had laid two eggs when these were appropriated by some boys, and the persistent little birds once more took the much-transported nest material and returned to a tree near the site of the first nest, where they built their fourth nest and reared three young.

The last of the group, the crested flycatcher, is in some respects the most remarkable. It is less inclined to be sociable than the others, and even though it may nest within a few rods of a human habitation in some cases, in others it is found in much more wild situations. It rather ignores man than avoids him. The erecting of the feathers of the crown, common to all of the tyrant flycatchers, finds an extreme in this bird, and it has almost an appearance of top-heaviness when, with crest fully erected, it sits on some open twig giving vent to its peculiar cries. Both the notes and the appearance of the birds at such times are quite ludicrous. This genus of flycatchers build their nests in hollows of trees, an old woodpecker's excavation, or more often a natural decayed cavity of a knothole. Many observers have stated that the bird invariably uses the cast skin of a snake in the construction of its nest, and it has been assumed that this was done for the purpose of frightening away enemies. In the few nests I have examined no snake skins were present.

On June 23 a nest was located in a knothole in a limb of an apple tree in an old orchard. It contained young about one-third grown, as far as I could judge. The following day a piece of board was nailed to a limb in such a manner that the camera could be clamped to it about three feet from the nest. A camera was clamped onto this board and left throughout the forenoon for the bird to become accustomed to. This camera was replaced about 2 P. M. by another with a long tube connected, at the end of which was a bicycle pump. The birds made trips to the nest with food at periods which varied in length according to the readiness with which prey was secured. At the distance of the tube's length it was not possible even with a good opera glass to identify the insects brought, save in one instance, where the prey was a large dragonfly. The birds upon alighting in the tree would sit quietly for several minutes eying the camera, then drop to the nest entrance and either cling for a moment to take a last look around, or immediately dive in. They were usually inside not more than from fifteen to thirty seconds. On an occasion when a bird took in a dragonfly, the wings were not first removed, and it was evidently not broken up before delivering to the young, as the time spent inside was shorter than usual. When the parent had delivered food it backed out (the cavity was too narrow to permit of turning) and for the first few times clung to the entrance for a moment; but thereafter it dropped and flew instantly. Small as were the young, they gave a very good miniature imitation of the weird cry of this species, when they heard the parents coming. July 1 the young flycatchers had left the nest, and though I heard the cry of the parents occasionally from a distance, I did not again see any of the family.

The spring dates of arrival from the South of these flycatchers is given as phœbe, March 10 to 20; least flycatcher, April 20 to 30; crested flycatcher and kingbird, May 1 to 10; wood pewee, May 10 to 20. Dates of departure for their southern winter homes: Kingbird, wood pewee, and crested flycatcher, September 20 to 30; least flycatcher, October 1 to 10; phœbe, October 20 to 30.

THE PHYSICS OF THE EARTH.

PROF. SEE'S FARTHER RESEARCHES.

THE September number of the Proceedings of the American Philosophical Society, held at Philadelphia, which has just appeared, contains an important paper entitled "Farther Researches on the Physics of the Earth, and especially on the Folding of Mountain Ranges, and the Uplift of Plateaus and Continents Produced by Movements of Lava beneath the Crust arising from the Secular Leakage of the Ocean Bottoms," by Prof. T. J. J. See, U.S.N.

In three previous papers during the past two years Prof. See has dealt with the cause of earthquakes and mountain formation, and developed a new theory that mountains are due to the secular leakage of the ocean.

This leakage of water into the heated layer beneath gives rise to movements of lava beneath the crust, and the result is the formation of mountains along the borders of the ocean. Lava is pushed from under the oceans, and it uplifts the crust along the edges of the continents into mountains. This new theory of mountain making has awakened worldwide interest among scientists, and already is generally accepted by the leading investigators of America and Europe.

In the present paper Prof. See takes up especially the folding of complex mountain ranges such as the Alps and Alleghanies, and shows that in all cases the folding was done in the sea, and by movements of lava beneath the crust in earthquakes. Where the Blue Ridge now stands there was once a deep sea, and the crust was folded into successive ridges, just as it is now being folded in the neighborhood of the Aleutian Islands.

In the same way he shows that the Alps were folded in the sea, and the folds so far inverted that they flared out at the tops, giving overturned dips. This formation of fan-shaped structures has been very difficult to explain heretofore, in fact it has completely bewildered geologists for more than a hundred years. They were unable to account for the extreme wrinkling of the earth's crust, on the theory that the earth was shrinking; but it never occurred to them that mountains are after all formed by the sea, and not at all by the shrinkage of the earth. By means of this new theory, Prof. See finds that all the difficulties disappear; and one can see how the mountains were folded almost as clearly as if he were an eyewitness to processes which took place many millions of years ago. He does this chiefly by comparing mountains now far inland with those now forming in the depths of the sea. The latter is a *living range* now developing; while the former is a *fossil range*, already dead and far inland.

It follows from this theory that the older mountains are most remote from the sea, while the newer ranges are near the sea, and sometimes still under water. The reader can thus traverse whole geological ages in his imagination, and foretell events which will even outlast the race itself.

In the last part of the paper Prof. See deals with the uplift of plateaus and continents. This is all due to the sea, which by its leakage causes the lava beneath the crust to expand, and finally push out at the edges. This earthquake process has gone on so long that it has at length uplifted whole continents. Charles Darwin, the famous author of the "Origin of Species," long ago asserted that the forces which slowly and by little starts uplift continents, and those which at successive periods pour forth volcanic matter from open orifices, are identical; but heretofore it could not be proved.

Having found by the processes now at work in the depths of the sea just how mountains are formed, Prof. See shows that all the great plateaus of the globe were uplifted by this same process; which consists in the expulsion of lava from beneath the sea and the pushing of it under the land.

All the great plateaus of the world face the Pacific Ocean, and about the border of this great ocean is what is called the World Ridge. It is a lofty ridge of mountains and plateaus running along the Andes and Rocky mountain chain in America, and then down the east coast of Asia and the Himalayas on the south, toward the Indian Ocean; then down the east coast of Africa. This World Ridge includes all the highest land of the globe, and it everywhere faces the water hemisphere. Prof. See shows that the World Ridge arose by the expulsion of lava from beneath the sea under the land hemisphere of the globe. The lighter material pushed under the land, he says, causes that hemisphere to float largely above the water, while the other hemisphere is almost completely submerged. This explains the cause of the land and water hemisphere of the globe, which has always been so utterly bewildering to men of science.

The discovery and definite assignment of the cause which sustains the earth in equilibrium between the land and water hemispheres is justly regarded as a scientific triumph of the first order. This must be regarded as not the least remarkable among several interesting results on the physics of the earth, deduced from the principle of the secular leakage of the oceans. Earthquake volcanoes, mountain formation, the uplift of islands, plateaus, and continents, seismic sea waves, trenches and holes in the bottom of the sea, the feeble attraction of mountains and plateaus, the equilibrium of the earth between the land and water hemispheres, are all clearly related and dependent upon a single physical cause.

In view of the order and harmony this establishes among the various phenomena, who will not concur in the view of the great Newton, that "Nature is pleased with simplicity, and affects not the pomp of superfluous causes"?

GERMAN KIESELGUHR.

KIESELGUHR, or infusorial earth, is used as filling material for soap, sealing wax, paints, and colors, and for the manufacture of dynamite, aniline, and alizarin, water glass, cement, mortar, artificial stone, gutta percha and caoutchouc articles, and for a variety of other purposes. It is found in considerable quantities in Hanover. It is a light flour-like mass—gray, brownish, or light green—feels soft and dry to the touch, absorbs water, and in ordinary temperature resists chemical action. It is found in layers in alluvial soil, or in the vicinity of lignite deposits. Large quantities exist near Huetzel in the Lüneberger Heide, and also near Unterluess in the same part of Hanover. The kieselguhr extracted at Huetzel is dried only in the open air, and it is generally cleaned before being used. Kieselguhr is also found near Vogelsberg in Hessen, at Jastrabe in Hungary, near Franzensbad in Bohemia, in Tuscany, Sweden, Finland, and also in Canada. The principal characteristics of kieselguhr are the low specific weight it has, which is 0.250 to 0.550, the high absorption, and its quality of being a very bad conductor of heat, making it one of the most reliable means of protection against the radiation of heat. The method of extraction is similar to that of clay for the manufacture of bricks. The product is removed from the open pit, and then spread upon benches, or hill sides, for the purposes of drying by air or sun. Artificial drying processes—by means of hot air—in rooms, drums, or troughs, have not, it is said by the American consul at Hamburg, proved practical in Germany. Kieselguhr roasts easily, but must never be brought into contact with a flame, as it would soon calcinate. The drying of kieselguhr in ovens would not be profitable, and such process would never come into consideration in large concerns. Several processes of drying kieselguhr, by using mechanical means, have been tried in Germany during the last twenty years, but have not proved satisfactory, and have therefore all been discarded. Kieselguhr has also been dried by means of hot air and exhausters, but this process is one applied only in wet weather, in exceptional cases, and with material which has already been dried to a certain extent. This process, however, is not remunerative, and can only be applied with the best quality of kieselguhr—washed for the manufacture of dynamite—and at a time when the market is at a high level. It has to be taken into consideration that kieselguhr contains, as it is extracted, 70 to 90 per cent of water, which evaporates very slowly. Air-dried kieselguhr still contains from 15 to 25 per cent of water. After having been dried, it is ground, and packed in sacks. During transportation, special care is taken to protect the product against moisture. For crushing mills, there are four different systems in use in Germany.—Journal of the Royal Society of Arts.

Deposits of sodium nitrate, or Chile saltpeter, have been found only in Chile. In the district of Tampa, near the port of Iquique, are extensive beds of nitrate, from 10 to 40 inches thick, covered with a layer of sand from 20 to 80 inches in depth. The crude nitrate, or *caliche*, contains from 48 to 75 per cent of sodium nitrate and from 20 to 40 per cent of sodium chloride. This composition indicates that the deposits are of marine origin. From 1830 to 1907, nearly 40 million tons of nitrate, worth more than one thousand million dollars, have been taken from these beds. In the northern part of Chile are other deposits. These have been little worked, but a company has been formed in London, with a capital of nearly nine million dollars, for their exploitation. Extensive deposits of phosphates have recently been discovered in the island of Mauru, in the Marshall group. Borings have revealed the existence of a stratum of phosphates from 10 to 15 feet in thickness, underlying the entire island. Already about 200,000 tons are exported annually to Japan, Australia, New Zealand, Hawaii, and Europe, particularly Germany. Deposits of phosphates in the forms of phosphorite and apatite are found in Florida and in the province of Estremadura, in Spain.

SOME CURIOUS OLD BOTTLES.

THE BOTTLE-MAKER OF THE PAST AND HIS CRAFT.

BY THOMAS OXLEY.

Along with almost every article of everyday use, the common wine bottle of to-day has its history and development, resulting in the cylindrical bottle as we now know and use it. It is interesting to study the various shapes and forms into which it has been fashioned, not only on account of its utility as a receptacle for wine and other liquors, but also as affording a very

DATED AND STAMPED WITH MERCHANT'S NAME.

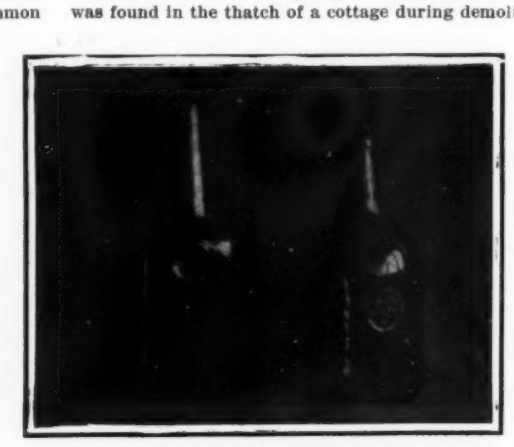
considerable amount of information on the use and manufacture of British dark glassware. The wines sent into England from the Continent of Europe come, and always have done so, in bulk, i.e., in the cask, which necessitates the bottle being provided by the merchant to retail the wine to the users and consumers, and as the cost of the bottle has to be included in the price of the liquor, it follows that it must be produced at a low price. Obviously a home-made article produced on or near the spot would be used in preference to a foreign-made article, on which cost of transit would have to be put, and that on a somewhat bulky article in proportion to its value. It will thus be seen that the question whether the bottle shall be made in England admits of no manner of doubt; the fact of dark glass being chiefly used is also of interest, especially when it is borne in mind that, at the present time, it has survived almost exclusively for the holding of wine. This may be for two reasons; in the first place, the materials used, being common, do not require clearing or even care in their selection, while the dark color, with its consequent interference with the rays of light, would, and does, prevent the color of the wine from being in any way affected by the light rays, and bleaching action or discoloration is avoided.

Perhaps the most interesting point in connection with the history of the bottle is the custom which obtains of having the name of the merchant impressed upon its surface. This fashion has been in use for at least 240 years, and to it we owe a great amount of the information we now have concerning the history of British glassware, though it must be confessed there is still much to be learned. It was, as is well known to antiquaries, the fashion in the latter part of the seventeenth and the whole of the eighteenth century to put the date—or, rather, the year—upon things, and this was much in evidence on wine bottles. For one thing, the year may have been used to indicate that particular vintage, and possibly for choice and expensive wines special bottles would be made, bearing the merchant's name and the year. These names and figures were impressed upon the side or shoulder of the bottle, on a small dab of glass placed there for that purpose, much in the same way that the impression of a seal is affixed to a letter in wax. Other devices were sometimes used, such as a coat of arms, or crest, and occasionally initials. These would indicate that the bottles were specially made for the consumer of the wine, and, being so, would be continuously used, over and over again, especially so as the cost of the bottles themselves must have been a considerable item in bygone times. It would appear that the earliest form made in this country was a simple bulb blown on the end of a long neck, and roughly provided at the mouth with an encircling ridge, so that a cover could be tied on underneath the ridge to cover the cork or stopper. This projection is very pronounced, vigorously indicating the purpose for which it is placed there. The bottle on the right-hand side of one picture is a typical illustration of this early form; the seal is impressed with the figure of the crowned leopard heraldically displayed, from which its date may be assumed to be somewhat about the end of the sixteenth century, and it is quite Tudor in style. The surface of this specimen is much decomposed from having been buried, and was originally quite black, though slightly transparent. The other one, alongside, gives the next and first step toward a molded or shaped form, being blown in a larger bulb than the earliest; the straight side is produced by being rolled on a flat slab, the bottle thus assuming a more useful form both for capacity and handling. The approach to the cylindrical is here first suggested, and it gradually increases, with, of course, variations and exceptions, until it becomes the common wine bottle, truly cylindrical, of present everyday use. The earliest dated bottles at present known partake of this form, which, in all probability, was that in use in nearly the whole of the seventeenth century. A number of these have been found in making the excavations for foundations in and about the city of London from time to time, and when found the surface is decomposed, and frequently beautifully iridescent, as is this specimen. It will be observed that the shoulder is almost a corner, the roundness of outline being between the neck and the shoulder. From this time the form of the outline began to reverse, the corner being at the base of the neck, and the round on the shoulder; this is well shown in another of the illustrations. These bottles have impressed upon them "Williamson Alford, 1723," and "I. Bilton, 1729," respectively. Similar in form, the workmanship of the impressing seal is very different; in the former it is excellent, while in the latter it is rude and irregular.

EARLY SEVENTEENTH CENTURY.

The larger bottle in the same picture is similar, but a little more symmetrical in contour; it is lettered "W. Stinton," and dated the memorable year "1745." Along with it is a smaller bottle of the earlier type "Rd. Cooke," 1734, showing an overlapping of periods usual in historical research. The cup between is of dark, somewhat coarse glass, and of early date; it was found in the thatch of a cottage during demolition,

NAILSEA WARE.



EIGHTEENTH CENTURY.

and contained the smaller silver coins of James I. and Charles I., but none later, probably a hoard during the troublous times of the Commonwealth. The cup itself is much worn by usage, and may be estimated with a fair amount of accuracy as having been made in the early years of the seventeenth century, possibly about 1610. Somewhat surprising is the light green glass bottle in another illustration, initialed "C. L," and also dated "1734." At first sight it would appear as though this was a totally different type, but such is really not the case; it is the same, as is proved by the form of the neck, but the lower part is elongated by being pressed into an octagonal form, which, if it had not been so manipulated, would have been of the usual shape. The color of the glass, a bright clear sea green, the octagonal shape, with the general appearance of height in comparison to width, mark it as unusual. The other shown in this illustration is the more immediate ancestor; the width is more contracted, the body more cylindrical, and the height, in proportion to the diameter, much greater. This form was common in the later half of the eighteenth century; it was still hand-made, i.e., not blown in a mold, and the glass itself very black. This is lettered "G. R.," probably the royal monogram for George III. It is identical in shape, size, and color to one in the museum at Penrith, Cumberland, initialed "E. L.," and dated "1786." At the beginning of the nineteenth century the seal disappears, and the "blown in a mold" comes in, the hand-made bottle only surviving for the first few years, and for out-of-the-way purposes. Such a one is shown in one of the pictures, which is a fine specimen of what is known as splashed ware; it has a capacity of one gallon, and is 14 inches high, its use being to hold or carry beer at harvesting times. This ware was made at Nailsea, not far from Bristol, from the year 1794 to well on in the next century, the date of this bottle being about 1802, or possibly

1745. CIRCA 1620. 1784.

a year or two earlier. It will be noted that there is a decided tendency to go back to earlier forms in it, as evidenced by the taper neck and round-shouldered body, the handle adding greatly both to utility and elegance. Another point of interest is that, with the exception of the very earliest type, the "kink" in the bottom or underneath the bottle always has been quite as large in proportion as in the worst cases of the present time, the first one in the second illustration having a very large indentation, occupying at least one-third of the internal capacity.—Country Life (London).

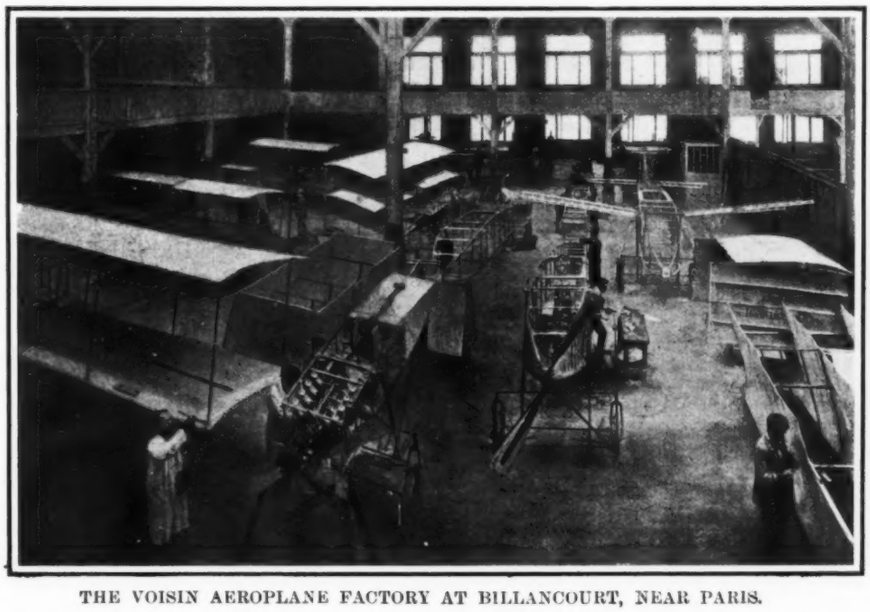
AN AEROPLANE FACTORY.

WHERE THE FRENCH MACHINES ARE BUILT.

THE largest and most successful aeroplane factory in the world is the establishment of the brothers Voisin at Billancourt, near Paris, where the machines of Farman and Delagrange were constructed. The workroom, filled with great flying machines and their separate parts, presents a strange and picturesque spectacle, but what especially impresses a thoughtful visitor is the facility with which an aeroplane can be constructed. Here he finds nothing remotely resembling the formidable battery of apparatus which is required in building automobiles. A saw, a plane, a few planks, and iron sockets, and a quantity of muslin and iron wire practically complete the list of machinery and materials. An aeroplane, with the exception of the motor, can be made more quickly and cheaply than a cab.

The planks, which are of well seasoned ash, white pine or poplar, and about 30 or 35 feet long, are sawn into strips from 2 to 2½ inches square. Four such strips, connected by uprights and cross pieces about 30 inches long fitted into iron sockets, form the *fuseau*, or axis of the aeroplane, which is made rigid by diagonal wire braces. On the *fuseau* are placed a seat and a back for the operator and an iron base for the motor. To each side is attached a wing which is constructed, like the *fuseau*, of four strips of wood connected by cross-pieces and stiffened with wire braces. The two wings extend to right and left in the same straight line and their combined length, including the breadth of the *fuseau*, is about equal to the length of the latter, from 30 to 35 feet. Each wing carries two horizontal aeroplanes of muslin. Nothing remains but to mount the motor, propeller and rudders. The system by which the rudders are controlled is simple and ingenious. Horizontal steering is effected by turning a wheel to right or left, and vertical steering by pushing the same wheel forward or pulling it backward. If the motor is ready, an aeroplane can be constructed and assembled in a week.

The current price of an aeroplane is $4,000 or $5,000, about half of which is for the motor. The high price is justified to some degree by the novelty of the industry and the infrequency of orders. It would appear that the cost of preliminary studies ought not to enter into the account. The calculations and theoretical considerations have been furnished, for the most part, by a number of disinterested persons, particularly Capt. Ferber and M. Armengaud, and aviators have gratuitously added the results of their experience. If the aeroplane, in becoming more practical and popular, retains its present simplicity, the cost of construction should not, and probably will not, exceed a few hundred dollars.—L'Illustration.



THE VOISIN AEROPLANE FACTORY AT BILLANCOURT, NEAR PARIS.

THE CONSERVATION OF RESOURCES.

THE schedule of investigations adopted by the National Conservation Commission is in general a carefully considered plan, that will be of much benefit even if but partially executed. Indeed, the plan is so ambitious that it is impossible to expect that all of the inquiries will be answered.

Referring to the question of minerals, which interests us most, it is possible to make a rough approximation of the country's resources in coal, lignite, and iron ore, but the determination of the reserves of oil, gas, and other ores is beyond the ability of all of the mining engineers and all of the mining geologists together. The dowser, or the electrical mineral indicator, who can really find ore, has not yet appeared; nor the man who can see into the ground.

The nature and extent of waste in the mining and use of mineral products, and methods of preventing or lessening the waste are good subjects for inquiry; also the more complete utilization of by-products and increased efficiency in the use of all products. But the answer to these questions is simple, viz., encourage the reading of the technical journals.

We venture to correct an academic misapprehension. Americans are commonly considered to be wasteful; this probably is the idea in Washington. We think that Americans are wasteful in some respects, but in others are paragons of economy. As consumers, we are prodigal of our wealth and scandalously wasteful; as producers, our utilitarian ideas lead us to be egregiously economical. Who does not know the captain of industry who is a skinflint in his factories, and a spendthrift in his home or his club?

It is important to define what is waste. Practically we prefer to accept the unphrased definition of the operator in the field rather than the words carefully formulated by the professor in his cabinet or laboratory, because the operator has learned to appreciate many things that the professor generally fails to consider. There is much apparent waste which in reality is not waste at all. For example, remark is frequently made of the immense quantity of sulphur which is thrown away in the treatment of sulphide ores; but it is not considered that the only use for such sulphur would be the manufacture of sulphuric acid, and that most of it is thrown away in parts of the country where there is no market for sulphuric acid, nor probably will be for a time more distant than we can clearly see ahead. If the ores were reserved for an indefinite time, interest charges would overwhelm them.

In all considerations of waste, the position of capital must be held prominently in mind. Resources can be reserved if capitalization be postponed until they are within the safe margin of profitable activity, their aspect until that time being as having no relation to commerce, just as if they were undiscovered treasures of nature. Otherwise, they would be saddled with colossal accumulations of interest, to avoid which wasteful exploitation would be compelled.

This is directly in line with many of our apparent wastes. For example, regenerative furnaces have never found so wide application in the United States as in Europe. The reason is that coal is dear in Europe and comparatively cheap in the United States; in the United States the saving of fuel, immense though it be, has not been sufficient to pay the interest and fixed charges upon the greater capital required for the plant. As coal increases in value, this condition will change. Engineers have long been conversant with the increased economy of gas engines, but for a long time they did not come into extensive use because the charges on greater cost of plant offset the apparent advantage in direct operation; as the cost of plant has been reduced, gas engines have come more extensively into use.

So it is through our whole line of industry. Only fifteen years ago we used to deplore that the United States possessed no chemical manufacture worth mentioning, save the rudimentary. So recently as that the time was not ripe for its development. But since then we have seen the growth of an immense chemical industry, utilizing by-product after by-product. This is something that our inventors and manufacturers may be relied on to attend to. A Gayley requires no artificial stimulus to increase the economy in making pig iron, nor does he need the efforts of a Federal commission to point out to him that there is a chance for effecting economy in that art.

Producers and manufacturers, with the aid of engineers and their other expert assistants, are aiming all the time to realize the most possible money from their resources. The improvements of specialists in the respective arts are sooner or later communicated to the technical periodicals and the transactions of the engineering societies, whereby the knowledge is disseminated through the whole industry. Consequently, as we said above, the simple answer to these inquiries of the National Conservation Commission is the encouragement of the reading of technical periodicals. The self-interest of the producer is in the direction of economy; if his immediate interest be different from that of posterity, capitalization must be prevented.

On the other hand, as consumers Americans are shockingly wasteful. This must be recognized immediately by every investigator, and herein it appears to us is the great field for the National Conservation Commission. We disgrace ourselves by our needless sacrifice of life and limb. We waste enormously in building by uneconomical methods. We suffer annually a gigantic loss through the destruction of property by fire. We burn our coal wastefully both in factory and in household. Our people are extravagant in their food and their clothing, not in using good things, but because they deliberately throw away a large part of what they buy. If Americans were as economical as the French, the wealth that this country would attain would surpass all belief. It is economy in living that has made the French people the bankers for the world.—Engineering and Mining Journal.

A rail-loading device capable of handling eight rails at a time has been devised for use on the Western Pacific Railway by Mr. T. J. Wyche, division engineer. It consists of two straight bars or yokes held apart by an iron pipe separator so as to have a span a few feet less than the length of the rails to be handled. To each yoke are attached eight bifurcated hooks, the two parts of which are about an inch apart, so that they straddle the web of the rail and catch under either the base or the head according to the way the rail is lifted, whether head up or head down. The hooks are strung along the yoke on heavy chains at the proper distances for piling rails in the customary fashion, one layer with heads up, and the other heads down, the latter fitting between the rails at the first layer. The device is swung from the boom of a locomotive crane, which is placed at one end of the flat car to be loaded or unloaded. The handling is done by first picking up eight rails, heads up, and placing them on the car, then following with the next lot of rails, heads down, so as to pile properly. The necessary splice bars are piled on two rails held by the hooks and then hoisted to place.

THE MOVEMENTS OF PLANTS.—III.*

IS GROWTH THE RESULT OF MEMORY?

BY FRANCIS DARWIN, M.A., PH.D., LL.D., F.R.S.

Concluded from Supplement No. 1709, page 211.

THE MNEMIC THEORY.

If the mnemic theory is compared with Weismann's views it is clear that it is strong precisely where these are weakest—namely, in giving a coherent theory of the rhythm of development. It also bears comparison with all theories in which the conception of determinants occurs. Why should we make elaborate theories of hypothetical determinants to account for the potentialities lying hidden in the germ-cell, and neglect the only determinants of whose existence we have positive knowledge (though we do not know their precise nature)? We know positively that by making a dog sit up and then giving him a biscuit we build up something in his brain in consequence of which a biscuit becomes the stimulus to the act of sitting. The mnemic theory assumes that the determinants of morphological change are of the same type as the structural alteration wrought in the dog's brain. The mnemic theory—at any rate, that form of it held by Semon and myself—agrees with the current view, viz., that the nucleus is the center of development, or, in Semon's phraseology, that the nucleus contains the engrams in which lies the secret of the ontogenetic rhythm. But the mode of action of the mnemic nucleus is completely different from that of Weismann. He assumes that the nucleus is disintegrated in the course of development by the dropping from it of the determinants which regulate the manner of growth of successive groups of cells. But if the potentiality of the germ nucleus depends on the presence of engrams, if, in fact, its function is comparable to that of a nerve-center, its capacity is not diminished by action; it does not cast out engrams from its substance as Weismann's nucleus is assumed to drop armies of determinants. The engrams are but cut deeper into the records, and more closely bonded one with the next. The nucleus, considered as a machine, does not lose its component parts in the course of use. We shall see later on that the nuclei of the whole body may, on the mnemic theory, be believed to become alike. The fact that the mnemic theory allows the nucleus to retain its repeating or reproductive or mnemic quality supplies the element of continuity. The germ-cell divides and its daughter cells form the tissues of the embryo, and in this process the original nucleus has given rise to a group of nuclei; these, however, have not lost their engrams, but retain the potentiality of the parent nucleus. We need not, therefore, postulate the special form of continuity which is characteristic of Weismann's theory. We may say, therefore, that the mnemic hypothesis harmonizes with the facts of heredity and ontogeny. But the real difficulties remain to be considered, and these, I confess, are of a terrifying magnitude. The first difficulty is the question how the changes arising in the soma are, so to speak, telegraphed to the germ-cell. Hering allows that such communication must at first seem highly mysterious. He then proceeds to show how by the essential unity and yet extreme ramification of the nervous system all parts of the body are so connected that what happens in one echoes through the rest, so that from the disturbance occurring in any part some notification, faint though it may be, is conveyed to the more distant parts of the body. A similar explanation is given by Nägeli. He supposes that adaptive, in contradistinction to organic, characters are produced by external causes; and since these characters are hereditary there must be communication between the seat of adaptation and the germ-cells. This telegraphic effect is supposed to be effected by the network of idioplasm which traverses the body, in the case of plants by the intercellular protoplasmic threads. Semon faces the difficulty boldly. When a new character appears in the body of an organism, in response to changing environment, Semon assumes that a new engram is added to the nuclei in the part affected; and that, further, the disturbance tends to spread to all the nuclei of the body (including those of the germ-cells), and to produce in them the same change. In plants the flow must be conceived as traveling by intercellular plasmic threads, but in animals primarily by nerve-trunks. Thus the reproductive elements must be considered as having in some degree the character of nerve-cells. So that, for instance, if we are to believe that an individual habit may be inherited and appear as an instinct, the repetition of the habit will not merely mean changes in the central nervous system, but also corresponding changes in the germ-cells. These will be, according to Semon, excessively faint in comparison to the nerve-engrams, and can only be made efficient by prolonged action. Semon lays great stress on the slowness of the process of building up efficient engrams in the germ-cells. Weismann speaks of the impossibility of germinal engrams being formed in this way. He objects that nerve-currents can only differ from each other in intensity, and therefore there can be no communication of potentialities to the germ-cell. He holds it to be impossible that somatic changes should be telegraphed to the germ-cell and be reproduced ontogenetically—a process which he compares to a telegram dispatched in German and arriving in Chinese. According to Semon what radiates from the point of stimulation in the soma is the primary excitation set up in the somatic cells; if this is so, the radiating influence will produce the same effect on all the nuclei of the organism. My own point of view is the following: In a plant (as already pointed out) the ectoplasm may be compared to the sense-organ of the cell, and the primary excitation of the cell will be a change in the ectoplasm; but since cells are connected by ectoplasmic threads the primary excitation will spread and produce in other cells a faint copy of the engram impressed on the somatic cells originally stimulated. But in all these assumptions we are met by the question to which Weismann has called attention—namely, whether nervous impulses can differ from one another in quality? The general opinion of physiologists is undoubtedly to the opposite effect—namely, that all nervous impulses are identical in quality. But there are notable exceptions, for instance, Hering, who strongly supports what may be called the qualitative theory. I am not competent to form an opinion on the subject, but I confess to being impressed by Hering's argument that the nerve-cell and nerve-fiber, as parts of one individual (the neuron), must have a common irritability. On the other hand there is striking evidence, in Langley's experiments on the cross-grafting of efferent nerves, that here at least nerve impulses are interchangeable and therefore identical in quality. The state of knowledge as regards afferent nerves is, however, more favorable to my point of view. For the difficulties that meet the physiologist—especially as regards the nerves of smell and hearing—are so great that it has been found simpler to assume differences in impulse-quality, rather than attempt an explanation of the facts on the other hypothesis. On the whole it may be said that, although the trend of physiological opinion is against the general existence of qualitative differences in nerve-impulses, yet the question cannot be said to be settled either one way or the other. Another obvious difficulty is to imagine how within a single cell the engrams or potentialities of a number of actions can be locked up. We can only answer that the nucleus is admittedly very complex in structure. It may be added (but this is not an answer) that in this respect it claims no more than its neighbors; it need not be more complex than Weismann's germ-plasm. One conceivable simplification seems to be in the direction of the pangenes of De Vries. He imagines that these heritage-units are relatively small in number, and that they produce complex results by combination, not by each being responsible for a minute fraction of the total result. They may be compared to the letters of the alphabet which by combination make an infinity of words. Nägeli held a similar view. "To understand heredity," he wrote, "we do not need a special independent symbol for every difference conditioned by space, time, or quality, but a substance which can represent every possible combination of differences by the fitting together of a limited number of elements, and which can be transformed by permutations into other combinations." He applied (*loc. cit.*, p. 59) the idea of a combination of symbols to the telegraphic quality of his idioplasm. He suggests that as the nerves convey the most varied perceptions of external objects to the central nervous system, and there create a coherent picture, so it is not impossible that the idioplasm may convey a combination of its local alterations to other parts of the organism. Another theory of simplified telegraphy between soma and germ-cell is given by Rignano. I regret that the space at my command does not permit me to give a full account of his interesting speculation on somatic inheritance. It resembles the theories of Hering, Butler, and Semon in postulating a quality of living things, which is the basis both of memory and inheritance. But it differs from them in seeking for a physical explanation or model of what is common to the two. He compares the nucleus to an electric accumulator which in its discharge gives out the same sort of energy that it has received. How far this is an allowable parallel I am not prepared to say, and in what follows I have given Rignano's results in biological terms. What interests me is the conclusion that the impulse conveyed to the nucleus of the germ-cell is, as far as results are concerned, the external stimulus. Thus, if a somatic cell (A) is induced by an external stimulus (S) acting on the nucleus to assume a new manner of development, a disturbance spreads through the organism, so that finally the nuclei of the germ-cells are altered in a similar manner. When the cellular descendants of the germ-cells reach the same stage of ontogeny as that in which the original stimulation occurred, a stimulus comes into action equivalent to S as regards the results it is capable of producing. So that the change originally wrought in cell A by the actual stimulus S is now reproduced by what may be called an inherited stimulus. But when A was originally affected, other cells, B, C, D, may have reacted to S by various forms of growth. And therefore, when during the development of the altered germ-cell something equivalent to S comes into play, there will be induced, not merely the original change in the development of A, but also the changes which were originally induced in the growth of B, C, D. Thus, according to Rignano, the germ nucleus releases a number of developmental processes, each of which would, according to Weismann, require a separate determinant. If the view here given is accepted, we must take a new view of Weismann's cases of simultaneous stimulation, i. e., cases like Fischer's experiments on *Arctia caja*, which he does not allow to be somatic inheritance. If we are right in saying that, the original excitation of the soma is transferred to the germ-cell, and it does not matter whether the stimulus is transferred by "telegraphy," or whether a given cause, e. g., a low temperature, acts simultaneously on soma and germ-cell. In both cases we have a given alteration produced in the nuclei of the soma and the germ-cell. Nägeli used the word telegraphy to mean a dynamic form of transference, but he did not exclude the possibility of the same effect being produced by the movement of chemical substances, and went so far as to suggest that the sieve tubes might convey such stimuli in plants. In any case, this point of view deserves careful consideration. Still another code of communication seems to me to be at least conceivable. One of the most obvious characteristics of animal life is the guidance of the organism by certain groups of stimuli, producing either a movement of seeking (positive reaction) or one of avoidance (negative reaction). Taking the latter as being the simplest, we find that in the lowest as in the highest organisms a given reaction follows each one of a number of diverse conditions which have nothing in common save that they are broadly harmful in character. We withdraw our hands from a heated body, a prick, a corrosive substance, or an electric shock. The interesting point is that it is left to the organism to discover by the method of trial and error the best means of dealing with a sub-injurious stimulus. May we not therefore say that the existence of pleasure and pain simplifies inheritance? It certainly renders unnecessary a great deal of detailed inheritance. The innumerable appropriate movements performed by animals are broadly the same as those of their parents, but they are not necessarily inherited in every detail; they are rather the unavoidable outcome of hereditary but unspecialized sensitiveness. It is as though heredity were arranged on a code-system instead of by separate signals for every movement of the organism. It may be said that in individual life the penalty of failure is pain, but that the penalty for failure in ontogenetic morphology is death. But it is only because pain is the shadow cast by Death as he approaches that it is of value to the organism. Death would be still the penalty of creatures that had not acquired this sensitiveness to the edge of danger. Is it not possible that the sensitiveness to external agencies by which structural ontogeny is undoubtedly guided may have a similar quality, and that morphological variations may also be reactions to the edge of danger? But this is a point of view I cannot now enter upon. It may be objected that the inheritance of anything so complex as an instinct is difficult to conceive on the mnemic theory. Yet it is impossible to avoid suspecting that at least some instincts originate in individual acquirements, since they are continuous with habits gained in the lifetime of the organism. Thus the tend-

* Presidential address before the British Association for the Advancement of Science at Dublin.

ency to peck at any small object is undoubtedly inherited; the power of distinguishing suitable from unsuitable objects is gained by experience. It may be said that the engrams concerned in the pecking instinct cannot conceivably be transferred from the central nervous system to the nucleus of the germ-cells. To this I might answer that this is not more inconceivable than Weismann's assumption that the germ-cell chances to be so altered that the young chicken pecks instinctively. Let us consider another case of what appears to be an hereditary movement. Take, for instance, the case of a young dog, who, in fighting, bites his own lips. The pain thus produced will induce him to tuck up his lips out of harm's way. This protective movement will become firmly associated with, not only the act of fighting, but with the remembrance of it, and will show itself in the familiar snarl of the angry dog. This movement is now, I presume, hereditary in dogs, and is so strongly inherited by ourselves (from simian ancestors) that a lifting of the corner of the upper lip is a recognized signal of adverse feeling. Is it really conceivable that the original snarl is due to that unspecialized stimulus we call pain, whereas the inherited snarl is due to fortuitous upsets of the determinants in the germ-cell? I am well aware that many other objections may be advanced against the views I advocate. To take a single instance, there are many cases where we should expect somatic inheritance, but where we look in vain for it. This difficulty, and others equally important, must, for the present, be passed over. Nor shall I say anything more as to the possible means of communication between the soma and the germ-cells. To me it seems conceivable that some such telegraphy is possible. But I shall hardly wonder if a majority of my hearers decide that the available evidence in its favor is both weak and fantastic. Nor can I wonder that, apart from the problem of mechanism, the existence of somatic inheritance is denied for want of evidence. But I must once more insist that, according to the mnemic hypothesis, somatic inheritance lies at the root of all evolution. Life is a gigantic experiment which the opposing schools interpret in opposite ways. I hope that in this dispute both sides will seek out and welcome decisive results. My own conviction in favor of somatic inheritance rests primarily on the automatic element in ontogeny. It seems to me certain that in development we have an actual instance of habit. If this is so, somatic inheritance must be a *vera causa*. Nor does it seem impossible that memory should rule the plasmic link which connects successive generations—the true miracle of the camel passing through the eye of a needle—since, as I have tried to show, the reactions of living things to their surroundings exhibit in the plainest way the universal presence of a mnemic factor. We may fix our eyes on phylogeny and regard the living world as a great chain of forms, each of which has learned something of which its predecessors were ignorant; or we may attend rather to ontogeny, where the lessons learned become in part automatic. But we must remember that the distinction between phylogeny and ontogeny is an artificial one, and that routine and acquisition are blended in life. The great engine of natural selection is taunted nowadays, as it was fifty years ago, with being merely a negative power.

I venture to think that the mnemic hypothesis of evolution makes the positive value of natural selection more obvious. If evolution is a process of drilling organisms into habits, the elimination of those that cannot learn is an integral part of the process, and is no less real because it is carried out by a self-acting system. It is surely a positive gain to the harmony of the universe that the discordant strings should break. But natural selection does more than this; and just as a trainer insists on his performing dogs accommodating themselves to conditions of increasing complexity, so does natural selection pass on its pupils from one set of conditions to other and more elaborate tests, insisting that they shall endlessly repeat what they have learned, and forcing them to learn something new. Natural selection attains in a blind, mechanical way the ends gained by a human breeder; and by an extension of the same metaphor it may be said to have the power of a trainer—of an automatic master with endless patience and all time at his disposal.

INDUSTRIAL DUST AND DISEASE.

THE MORTALITY IN ENGLISH FACTORIES.

In the Section of Industrial Diseases at the recent meeting of the British Medical Association in Sheffield a discussion took place of the first importance to the workers in that city of stones and steel. Dr. Kerfield, Medical Officer of Health for Sheffield, opened with a paper entitled "The Mortality in Dusty Trades in Sheffield." The keynote was struck in his first words. "The 'dusty' trades" of Sheffield produce their chief effect by increasing the fatality of consumption and diseases of the breathing apparatus. The tale of misery and death which has overwhelmed the workers in these trades ever since machine grinding commenced is appalling in its magnitude and horror. The economic loss to the community of so many men struck down in the prime of their working lives cannot be stated in cold figures, but must be of immense proportions. Consider, that of the population over 25 years of age, the proportionate deaths of males to females from consumption are as 4 to 2 all over England, but are as 6 to 2 in Sheffield, and the necessity for the sternest measures for improving the conditions of the working places of these men will be only too evident. The death-rate from phthisis among the grinders is 16.3 per 1,000, while among the general male population it stands at 2.6. The rate among the cutlers is 7.2. Can this awful mortality be prevented? To answer this question it is first of all essential to understand how the dust causes" the disease.

Prof. Thomas Oliver, and other medical authorities, are agreed that the dust so acts upon the tissue of the lungs as to produce a chronic irritation, giving rise to a patchy fibrosis of the substance of the lungs which renders them liable to the attack of the deadly tubercle bacillus. Dr. Oliver, however, maintained that this condition, known as pneumonokoniosis, may in some cases be fatal without the intervention of the tubercle bacillus. The factors, therefore, to be dealt with are the tubercle bacillus and irritating dust. It is of interest to note that such an authority as Sir T. Whitlea holds the opinion that the dust swallowed as well as breathed eventually reaches the lungs by the lymphatic channels. The bacillus is excessively acute, and a grain of dust might bear thousands of them into the lungs or stomach. Dr. A. E. Barnes, of Sheffield, is so convinced that the tubercle bacillus is the *fons et origo mali*, that he would direct all his efforts to abolishing this pest from the workshops, disregarding the dust. He said: "The simplest explanation of grinders' high mortality from tuberculosis is that the dust, by rendering easy the rapid spreading of the worker's sputum, simply aids in the dissemination of the bacilli." While the bacilli are kept in a moist medium their dissemination is impeded. Dr. Barnes declares that "to provide spittoons to receive the sputum" is the cheap and rational method to put an end to the scourge. We cannot help thinking that he reckons without the British workman, who is notoriously intolerant of interference with his liberty of free expectoration. Most of the speakers in the discussion were of opinion that "it would be a very inadequate solution of the problem to remove the tubercle bacilli; we must remove the dust."

As in so many other dangerous trades, the British workman has to be protected against himself. The difficulty of getting workers to take the most elementary precautions is "the cold inertia" that all reformers rail vainly against. Some years ago a strike was caused in Sheffield by the proposal to fit fans in the needle-grinding factories. The workers said truly, that if the trade became less dangerous—a needle grinder of 45 was an old man—the pay would be reduced, and they preferred a short life and a merry one. A millstone builder said, at a sitting of the Dangerous Trades Committee of the Home Office, "I know quite well the dangerous nature of the trade I am working at. . . . I run the risk because the work is well paid, and I can take plenty of days off." In Germany a method has been found to correct this attitude toward reform. As Mr. Ellis Barker said, "Both masters and men have a joint pecuniary interest in the matter of good health. Under the insurance laws of that country employers and workpeople contribute to insurance funds, which are managed by a joint committee of both." Sickness touches the workman in his pocket, so he adopts measures to enforce cleanliness, by fines, on his fellows.

We turn now to the mechanical aspect of the removal of the dangerous dust. Messrs. C. Johnston and S. R. Bennett, H. M. Inspectors of Factories, Sheffield, contributed a joint paper recounting experiments that were undertaken at the instance of Dr. Whitelegge, of the Home Office. They found that dry grinders were a much smaller class than the wet grinders, but that the latter in certain processes were much exposed to dust, notably in the process of "raising" a stone, i. e., roughening its surface. Artificial stones are just being introduced, which much reduce the dust trouble. These stones do not require to be "raised." The writers describe an ingenious apparatus for "raising" a grindstone with a continuous jet of water flowing on to the work, and a box over the stone. The method is an improvement on the old "dry" plan, for a hard stone was raised in two and a half hours that would have taken six to prepare. The problems to be solved are divided by the authors into four heads, the removal of:

(1) The heaviest particles, which fly nearly in straight lines for some distance, and then fall to the ground.

(2) Those whose initial velocity diminishing rapidly, float about for a short time, and then settle down near the stone.

(3) The lightest, which swirl from the peripheral current and float about, wafted by every eddy all over the room.

(4) Those which are carried completely round the stone, and impinge again on the body or hands of the grinder, or on the article ground.

Perfect ventilation requires that all the particles under these four heads should be carried away as the stone wears. Of course, no interference with the free action of the worker, or of the incidence of light, can be allowed. An air current is not in itself sufficient to remove particles found to be moving at a mile a minute; the initial momentum must be knocked out of them before the air current can become effective. Neglect of this truth has allowed the most deleterious dust, under headings 3 and 4, to remain unaffected by the air current, to the detriment of the workers. Ingenious but simple hoods and extractors have been designed by the authors, which they report to be entirely effective. The common practice of discharging the dust through the wall of the workroom into the outside air is justly condemned.

The mechanical portion of the problem, the removal of the dust, is soluble. It only remains to educate the worker not to transmit the deadly tubercle bacillus, to solve the human portion.—Engineering.

SEPTIC TANK EXPERIENCE AT STRATFORD-ON-AVON.

THE dry-weather sewage of Stratford-on-Avon, England, passes through screening and detritus chambers into four septic tanks having a total capacity of 450,000 gallons, and is then sent to eight sprinkling filters. The effluent from these is passed either to gravel beds of a total area of 2 acres or to an 8-acre irrigation tract. The storm-water sewage is screened and delivered to two pairs of contact filters. The dry-weather sewage is a little over 312,000 gallons. Each sprinkling filter is 85 feet in diameter and contains 5 feet of furnace clinker, which is graded in size from ¼ inch at the top to 2 inches at the bottom.

The sewage contains brewery and tannery wastes, which ferment quickly, particularly in warm weather, and it has been found undesirable to allow the septic action to continue longer in the tanks than about five hours, for a bad odor will otherwise result. As the sewage must all be pumped, any stopping of the pumps permits it to accumulate in the pump well where "fermentation" is likely to begin. While all the dry-weather sewage can be pumped readily in twelve hours, it has been found advisable for the reason mentioned to run the pumps more slowly and thus reduce to a minimum the changes in the character of the sewage before it reaches the septic tanks.

The filters are worked at an average rate of 212.9 gallons per square yard per day. The purification effected by the tanks and filters averages 88.6 per cent, measured by the four-hour oxygen absorption test, and is generally non-putrefactive. The effluent contains an average of 8 parts per million of nitric nitrogen. Irrigation increases the total purification to 93.7 per cent by the oxygen absorption test.—Engineering Record.

During the twelve months ending with June 30 the total imports of coal into the United States were 1,981,467 tons, as compared with 1,689,869 tons in the year immediately preceding, the bulk being from Canada. The exports in the year ending with June last were 12,782,735 tons, of which 2,837,778 tons were anthracite. Of the total shipments 11,121 tons went to France, 8,957 tons to Germany, 224,180 tons to Italy, and 51,429 tons to other parts of Europe. The total exports showed a considerable increase upon those of the previous year, when the quantity was 11,294,252 tons.

PNEUMATIC CAISSONS.—I.*

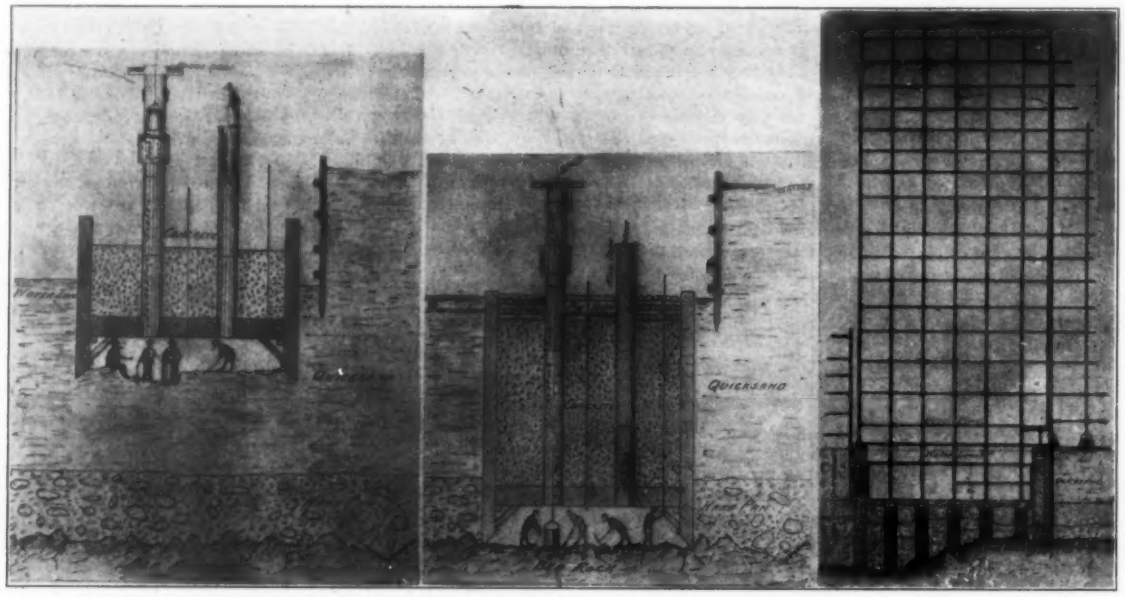
HOW THEY ARE EMPLOYED IN ENGINEERING CONSTRUCTION.

BY T. KENNARD THOMSON.†

Caissons, under the name of Plenum Pneumatic Process, were first used in America in 1852 for a drawbridge over the Harlem River at Third Avenue, where a number of cast-iron cylinders about 4 feet in diameter were sunk to support each pier.

for an ammunition carriage. It is often used to describe either open cofferdam work or pneumatic work, the first more by architects than engineers. Open cofferdam work, as the name would imply, is simply an excavation with supporting sides to prevent the

By working very quickly and steadily, caissons have been sunk through New York quicksands some 16 to 1 feet before air was applied, but the material becomes soggy very quickly, and it is more advisable to apply the compressed air from the start, generally beginning



CAISSON FAIRLY STARTED ON ITS WAY DOWN INTO THE QUICKSAND.

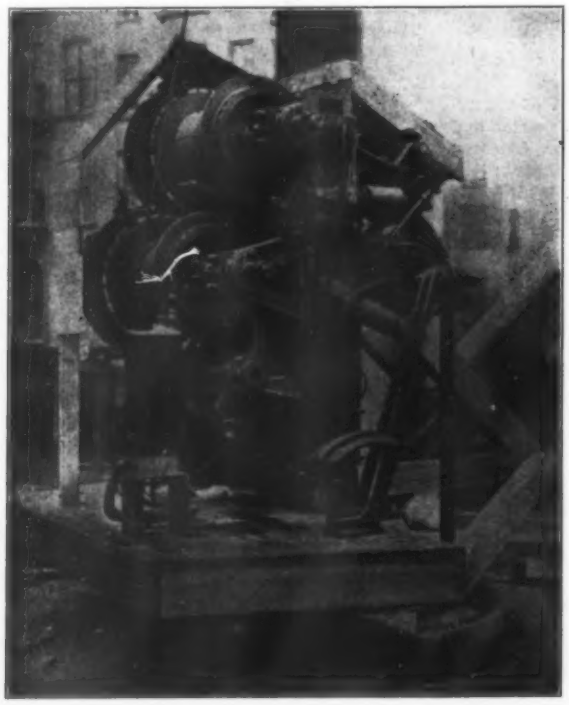
CAISSON DOWN, NEARLY READY FOR CONCRETE IN AIR CHAMBER.

MUTUAL LIFE BUILDING FOUNDATIONS.

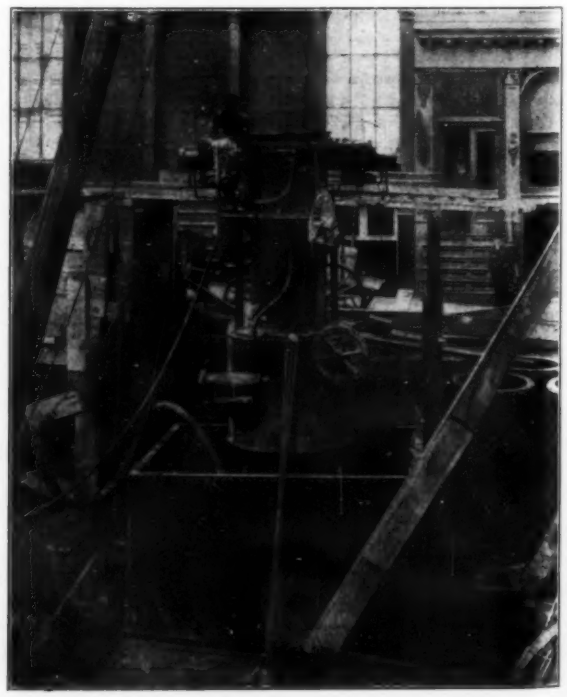
As the French had made some progress in this line, the contractors of the Third Avenue bridge brought a French engineer over at a high salary per diem, but after about a week, having learned all he could teach them, they let him go home, much to his disgust. This bridge was rebuilt by the city of New York some forty-three years later, using a modern large caisson instead of a number of small ones, and the old cylinders on being removed were found to be in very good condition.

surrounding material from caving in, while pneumatic work requires in addition a roof or floor some 6 or 7 feet above the cutting edge or bottom of the excavation. The roof can be a temporary one and removed after the cutting edge has reached bottom, or it can be left in place. While the roof has sometimes been put on top of the sides after they have been driven as far as they are to go, the practice is very rarely followed; one of the few cases being the Harlem River tunnel.

with 3 or 4 pounds, on account of operating the doors etc.; although theoretically the pressure should start at zero, for as the only object of the compressed air is to keep the water from flowing in, the pressure of the air should just balance the pressure of the water. The weight of fresh water is about 62½ pounds per cubic foot, or 0.434 pound per square inch on the bottom, so if the water is 10 feet deep the pressure will be 4.34 pounds per square inch, and if the depth is 1 feet the gage will show 43.4 pounds per square inch



ELECTRICAL HOIST FOR MAST; HUDSON TERMINAL BUILDINGS.



LOCK WITH TWO TOP HORIZONTAL SLIDING DOORS.

PNEUMATIC CAISSONS.

The word caisson is taken from the French *caisson*, from *caisse*, meaning a box or chest, and is also used

The usual method is to build the caisson first with the roof or deck about 6 or 7 feet from the cutting edge—the side having first been excavated to the water level—work in the open by cheap labor, of course, being cheaper than excavation in the air chamber by high-priced "sand hogs," with the cost of the compressor, plant, etc., in addition,

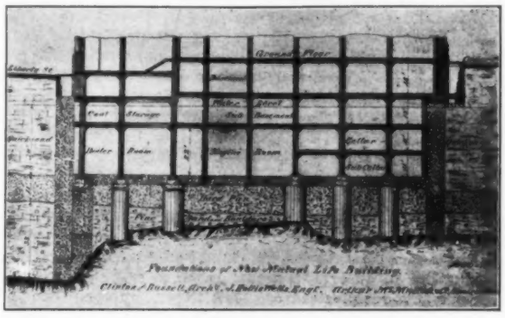
which is about the limit of pressure in which men have been able to work.

It would naturally be expected that caissons which are being sunk in a field or city might not have as great a water pressure at the same depths as a caisson which is being sunk in the middle of the river, but as a rule, the actual pressure required in both cases

* Reprinted by permission from Railroad Age Gazette.

† Mr. Thomson designed the caissons for the railroad bridges across the Monongahela River at Pittsburg, the Ohio River at Mingo Junction, the Susquehanna at Havre de Grace, the Missouri at Pierre, S. Dak., and others, and for the stone arch highway bridge over the Connecticut River at Hartford, Conn.

will not be found to vary much from the pressure calculated from the hydrostatic head of water. It is as dangerous to have too high a pressure as it is to have too little pressure, for if it is too high a blow-out will occur, suddenly reducing the pressure in the working chamber and allowing the outside material to rush in before the pressure can be raised again.



MUTUAL LIFE BUILDING FOUNDATIONS.

In the Rapid Transit tunnel under the Harlem River, which I have referred to, the sides were driven first and the roof was sunk from the surface on to the solid side walls of 12-inch x 12-inch sheeting so as to leave 25 feet of water above the roof at low tide, this being the government requirement. Instead of driving the 12-inch x 12-inch sheeting one at a time, the contractor bolted three of them together, and by spiking two 3 x 4-inch timbers on in such a way that one 3 x 4-inch piece on the adjoining three 12 x 12 would fit into it, formed a sort of tongue and grooved joint, which has proved very effective.

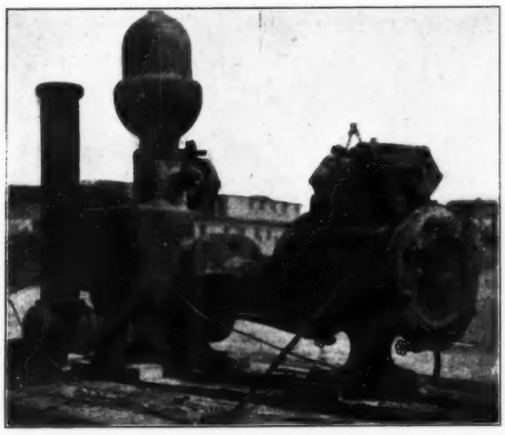
In this case the contractor did not wish to go to the expense of putting enough weight on the roof to withstand the entire air pressure which would be required to keep the water out of the air chamber; so he split the difference and used half the air pressure theoretically required, that is, from 10 to 12 pounds per square inch, and relied on the pumps to keep the water down. The pumps could not have handled the work without the assistance of the air pressure. This compromise plan proved successful, although the water broke in several times, giving the men a pretty good scare.

The success was undoubtedly due to the nature of the soil, clay, to a large extent, for this scheme would be too risky in a silty sand or gravel.

The first section to be sunk had a temporary roof under which the permanent roof was built after the material had been excavated, but the removal of this temporary roof, a solid wooden platform 3 feet thick, was found to be so expensive and tedious that the next section to be sunk had the permanent roof of cast-iron lining inside of the concrete with half the sides (that is, the entire upper half of the tunnel) built on floats so that when it was sunk in place all that remained to be done was to complete the lower half of the tunnel. This was not only much cheaper than the first plan, but also much safer, and was first suggested by the writer.

Fairly complete descriptions of the Harlem River tunnel will be found in the Engineering News and the Engineering Record of 1903.

For ordinary caissons, great variation has existed and still exists in the design and construction, some engineers using very thick timber walls with a timber roof or deck 10 or 12 feet thick, others reducing the thickness of the timber roof to 3 feet, while others again use plain concrete or reinforced concrete, and employ timber only for forms, while a few build the whole caisson and cofferdam of steel and cast iron. A good example of steel caissons was the Mutual Life Building, where the sizes ran from 3 feet diameter for underpinning cast iron caissons to 8 x 22 feet for the main caissons.



CAMERON PUMP

Several contractors in New York have recently tried sinking caissons of concrete only, using timber for forms and removing the forms as soon as possible. Theoretically, this method is the cheapest of all, but practically it has been found that it paid to leave an outside shell of timber on to permit the sinking to proceed continuously, which is not possible when removable forms are used, necessitating a cessation of sinking for a day or so, sometimes several times for each caisson, to permit the concrete to harden before being subjected to the friction of the ground. The removal of the forms required considerable labor, sometimes high-priced, as in the case where iron angles were used and the forms were held together by means of steel bolts, which gave the iron unions a chance to insist upon the bolts being put in and taken out by iron erectors.

Concrete also causes slightly greater friction than planed boards, especially where the latter are greased. Most people seem to object to grease on the concrete itself.

In New York, as in many other places, the least friction is obtained by gradual but continual sinking, for allowing the caisson to take a quick drop of several feet and then perforce allowing it to stand for some time, gives the quicksand and other material a chance to adhere to the sides of the caisson, causing a very considerable increase in the amount of friction which must be overcome before the caisson can start again. Using forms instead of permanent sides, of course, prevents continual sinking.

Friction is a very hard item to estimate, as it depends not only on the nature of the material but also on the method of sinking, and on one job in New York city where very careful records were kept it was found that the friction varied from 150 to 650 pounds per square foot of exposed surface, the material passed through being what is called New York quicksand.

In order to reduce the friction on the sides, nearly all beginners want to make the bottom of the caisson of larger cross-section than the top, thinking that as the hole excavated will thus be bigger than the caisson above the cutting edge, they will thus obtain very little or no friction, but this has been repeatedly found to be a mistake, for in most cases it results in the surrounding material "caving in" and jamming against the sides, increasing the friction enormously.

At the Hawkesbury bridge, in Australia, where cyl-

FOUNDATIONS FOR GERMAN-AMERICAN INSURANCE BUILDING, NEW YORK.

PNEUMATIC CAISSONS.

indrical open steel caissons or cofferdams were used which tapered from the bottom to the top, the material was excavated by dredging, and instead of the surrounding material flowing against the sides and causing a jam, as is the usual case, the reverse happened, and a water space or water-filled cavity was left around the sides, with the result that it was impossible to hold the caisson plumb. This gave so much trouble that material was dumped around the sides and then work was suspended for a year to allow the earth, etc., to pack around the caissons, after which sinking was resumed, successfully.

To give an example of the opposite result in this country, an engineer once divided his caisson into two piers above the deck, leaving an open space of some 20 feet between the two piers, and in addition the sides were battered, with the result that the bowlders, etc., caved in and jammed so firmly that some 1,200 extra tons of pig iron were required to overcome the friction—a very expensive experience for the contractors. As these contractors had to sink a second caisson of similar design, they profited by their experience and built a cofferdam on each side between the two piers and filled the space with earth, etc. They also built the sides vertical. While the railroad saved a few yards of concrete by dividing the caisson into two parts above the deck, and similar economies, it had to pay fully 50 per cent more per cubic yard for the next bridge it built immediately following, which shows that the mere cutting down of dimensions does not always mean economy.

Another favorite expedient, and an equally costly one, is trying to overcome friction by jetting, thus saving the purchase and handling of pig iron, which always consumes a great deal of time and money.

It is, of course, very easy to shove a jet pipe, of ¾-inch diameter or so, down the side of the caisson, and to pump water through the pipe at high pressure, at the same time moving the pipe around the caisson, overcoming the friction by forming a sort of water jacket around the sides, which allows the caisson to sink, or rather drop, several feet at a time. This can often be repeated several times to advantage, but it disturbs the surrounding ground to such an extent that, in many cases, the material cakes against the sides, making each succeeding operation harder than the one before.

The only economical method of sinking is to have just sufficient weight so that the caisson will continue to move downward as fast as the cutting edge is undermined. Too much weight is obviously dangerous, as in soft material there is a risk of the cutting edge penetrating the material until the air chamber is filled with earth and water, and even if the men have all had time to escape it is expensive work digging in from the shaft to make room for the men and buckets.

The usual method, after a caisson has fairly started on its downward course, is to dig about a foot below the cutting edge, except just around the cutting edge itself, then removing the material directly under the cutting edge itself, and by slightly reducing the air pressure for a very short interval the net weight of the caisson and its load is increased enough to overcome the friction and to allow the cutting edge to reach the bottom of the excavation. In many places, however, it is impossible to keep the water level below the cutting edge, in which case it is not usual to excavate below the cutting edge.

When passing through hard material, such as hardpan, bowlders, or rock, it is important to see that the excavation is made wide enough, or the caisson will surely become jammed. In fact, I have seen a 3-foot diameter cylindrical cast-iron underpinning caisson become so jammed that four hydraulic jacks aggregating 320 tons would not budge it, and as the jacks were acting against the wall of a building it was not considered safe to jack any more for fear of injuring the building that we were underpinning.

Much difference of opinion exists as to the proper form of the cutting edge, which, as might be inferred, is the bottom of the caisson, the idea being that it cuts its way into the underlying material, though as we have seen, it is often necessary to excavate under the cutting edge itself. Many strive to obtain a knife edge (for the cutting edge) by means of steel plates and angles; while I have in many cases contented myself with an 8-inch channel laid flat. The knife edge is, of course, ideal, but is very expensive, and where it is really needed is almost sure to become bent and distorted, in which case it is far worse than no cutting edge at all.

The cutting edge and sides should, of course, be designed with the object of giving the maximum room to work at or under the cutting edge, for, at the best, removing the material at the cutting edge is very much more expensive than removing the rest of the material.

While it is possible to analyze the strains in most structures, and it is possible to do so with a pneumatic caisson, still there is such a large element of personal judgment required that it is dangerous to lay down rules for others. Theoretically, if the air pressure just equals the outside pressure it might be argued that there are no strains on the sides or roof of the air chamber, but we know, as a matter of fact, that sometimes these strains are enormous and irresistible, especially when the caisson gets out of plumb or encounters harder material on one side than the other. Every experienced "sand-hog" or caisson man has seen the roof badly deflected and the sides twisted out of shape. So it is essential for the designer to use his eyes and his judgment. He should also be familiar with the methods of the contractor who will use his plans—for a design that would be quite safe for one contractor would not be at all safe for another.

All wooden caissons should have an outside tongued and grooved sheeting of 2-inch or 3-inch plank laid vertically to avoid friction on long horizontal joints. Most contractors, however, use plank with a calking edge instead of tongued and grooved, and then calk with oakum.

For small caissons, say from 5 feet to 12 feet square, there should be a horizontal wall of 8-inch or 10-inch timbers from the cutting edge to the roof instead of the plank sheeting, properly braced at the corners, and inside of this there should be a 12-inch x 12-inch belt course under the roof. One solid course of 12 x 12-inch timbers is ample for the roof or deck, and if concrete is placed on the deck as fast as the caisson is sunk, the plank sheeting will be sufficient for the side walls above the deck, with light horizontal waling pieces spaced about 5 feet apart vertically.

For large boxes, up to 30 feet wide, I have used, successfully, 27-inch sides, below the deck; that is, 3-inch plank against 12 x 12 horizontals, inside of which I placed a wall of 12 x 12 posts, about half of which extended from the cutting edge to the roof and the rest projected from 2 to 6 feet above the deck, while the corner posts and an indeterminate about every 15 feet apart were extended to the top of the cofferdam, properly spliced at the joints.

About the deck, horizontal 12 x 12-inch walings spaced from 3 to 5 feet apart vertically were placed outside of the posts, the sheeting being spiked to the walings.

If the concrete were placed in the cofferdam on top of the caisson as fast as the caisson was sunk, all the bracing above the deck could be removed as the concrete reached the bottom of the brace, or omitted altogether in some places, but it is often necessary to keep the concrete 20 to 30 feet lower than the surface of the water in order to prevent the caisson from becoming too heavy, when very heavy cofferdam bracing will be required to withstand the hydrostatic head. This is especially so when the water is deep, say over 30 feet, and bottom of the river consists of fine silt. Sixty feet of water is the deepest in which I have started a caisson.

For deep water work it is necessary to so design the caisson and plant that there will be no danger of turning turtle, lack of which provision has resulted in several accidents.

Reference has been made to the advisability of having a shell of timber or steel even where the concrete is always above ground while being deposited, in order to save time and expense, and it is also necessary to prevent new or green concrete from being parted by the friction of the ground.

In sinking the first caisson for a New York city skyscraper, the Manhattan Life Building, steel caissons were used, on top of which brick work was built, but it was found that the friction broke the new mortar, thus pulling the brickwork away from the caisson. In any case, the cofferdam should be very securely attached to the caisson, the necessity of which was proved in a river caisson where the clay was taken out of the air chamber and dumped over the side of the cofferdam to which it adhered, and broke the whole cofferdam, 106 feet long, away from the caisson.

Many small New York caissons have been built with wooden sides and a 2-inch plank "form" under the roof, on which 2 feet of concrete has been laid and allowed to set for a couple of days, after which the form was removed and the concrete continued. At first, forms were also used instead of cofferdams for the sides above the roof, but after this scheme had been used for three or four buildings it was abandoned as not economical in practice.

In these caissons, sometimes the steel shafts were left in, and in other cases collapsible steel shafts or wooden forms for the shafts were used and then removed. Removing or leaving out the steel shaft in a small caisson is very risky and has been attended by accidents where the caisson has broken in two owing to greater pressure on one side of the cutting edge than the other.

Steel caissons have been used a great deal in the past, but are not used in New York much now, except perhaps for circular caissons, especially where of very small diameter. The advantage of using steel for round caissons up to 10 or 12 feet in diameter, consists in the rapidity with which the light sections of cofferdam can be bolted on and filled with concrete, the time saved often being enough to pay for the extra cost of material. Another advantage is the ease with which they can be made water-tight.

MUTUAL LIFE BUILDING FOUNDATIONS.

Showing steel column in place before cellar was dug. Steel cofferdam around column being removed as digging of cellar proceeded.

Small caissons for underpinning purposes are made from 30 to 36 inches diameter, of cast iron or built up steel plates. A good plan is to use steel cutting edge sections and make the upper sections of cast iron, using 1½ to 2-inch metal. In underpinning the adjoining buildings to the extension of the Mutual Life Building, in 1900, we used twenty-six of the small caissons from 60 to 80 feet deep.

Twenty-seven inch inside diameter is the smallest pneumatic caisson we have worked men in, but they were cramped for room, and 33-inch inside diameter or 36-inch outside has been found to be a much better size.

For the main caissons of a new building, anything under 6 feet in diameter is unsatisfactory, as there is not sufficient room for the men and bucket, and besides it is hard to keep small caissons plumb and in line.

In the above only those caissons in which the roof is left in place have been considered, but there are many places where it is desired to sink the caisson shell with a temporary roof and, of course, a temporary weight; where, for instance, the base of the column must be set below the surface of the ground before the main part of the cellar is excavated. This has been done in a number of cases in New York in recent years, where there are from three to four floors below the street level, both for the purpose of saving time by allowing the erection of the steel work to

commence before the cellar is excavated, and also in order that the steel work and concrete floors may be used, as the cellar excavation proceeds, to obtain sufficient bracing for the side caissons, which are usually only 6 or 8 feet wide, forming a wall around the buildings sometimes 60 or 70 feet below the street line, and are entirely too light to withstand the enormous water and earth pressure without the horizontal bracing afforded by the floors.

It is necessary to use considerable common sense and experience in attempting to calculate the strains in a caisson. As regards the deck, for example, it is very easy to calculate the weight to be carried by the deck and the strains that would result therefrom, and we know that the air pressure acting up against the roof will counterbalance a great deal of this weight, making it, in fact, something like a pontoon floating in the water. But, on the other hand, the air pressure is often slacked down to almost nothing in order to overcome the friction and is raised again before much water has time to enter the working chamber; and sometimes an accident to the air plant will suddenly cut off the supply of air, throwing a tremendous strain on the roof. If the principal weight on the roof is concrete it will in many cases be self-sustaining unless too fresh.

The same with the sides; if the material were absolutely homogeneous all around and the caisson were sunk absolutely plumb, which almost never happens, and the air pressure were kept equal to the outside pressure, then we would have practically no strain on the sides—but all practical caisson men have seen the sides of caissons collapse, and some very strongly built ones at that. A very much more frequent cause of accident than loss of air pressure is to strike some obstruction on one side, deflecting the cutting edge, and thus throwing much of the weight of the caisson on the weakened side, making bad worse.

A caisson 8 feet wide has had its sides so distorted and compressed that there was not room left for a 2-inch bucket to enter the working chamber from the shaft. In this case the working chamber was made much too light to start with and collapses occurred in the working chamber, and a couple broke in two above the deck and had to be stopped where they were in the quicksand, some 20 feet above hard-pan, and the excavation continued under the cutting edge by lining the sides, as in the case of a vertical tunnel—a very risky proceeding, but successfully accomplished.

Some caissons have been sunk as much as 5 feet out of plumb, an inexcusable state of affairs for a small caisson, for while we have said that very few caissons are absolutely plumb, still there is no excuse for their being more than a few inches out.

Large concrete steel caissons have been sunk, and in one case it was claimed that by using reinforced concrete the company had saved $100,000 as compared with the cost of the steel caisson they had contemplated; but I have built an equally large caisson, 46 x 90 feet, of wood, the total cost of which was only about $25,000. So if the cost of the reinforced concrete caisson were compared with a wooden caisson it would be rather difficult to show a saving of $100,000. In building wooden caissons I very seldom halve the timbers or use dovetailed joints, preferring to use butt joints as much as possible with plenty of drift bolts. The trouble with butt joints, however, is that while a carpenter will make a dovetail or halve-joint tight he will probably leave an inch or so play in a butt joint.

The deck timbers as well as those in the sides should be planed on one side and one edge, for the sizes would otherwise vary too much to get a good job, while the calking for the outside and inside of the air chamber should be either tongue and groove, or the sides should be planed for a calking joint. The plank should, of course, have its faces also planed.

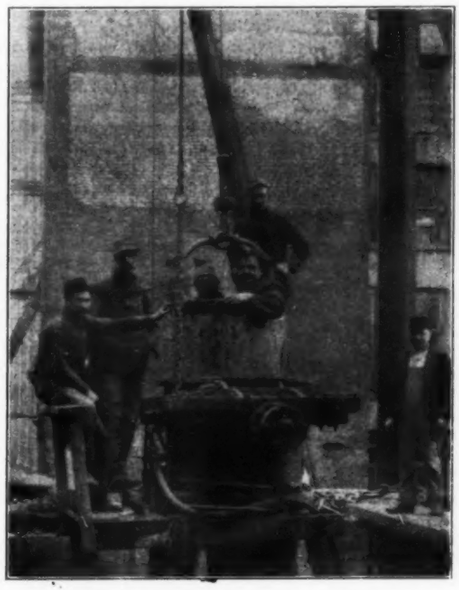
It is very important, and difficult, to keep the water out of the cofferdam, and it requires great care with the calking, for sometimes a joint under the cutting edge is not completely calked, with the result that the water finds its way up through the sides and into the roof or deck and thence through the concrete, forming a very bad leak which it is impossible to stop, as the location cannot be discovered. This often necessitates continual pumping in the cofferdam while new concrete is being deposited, which is, to say the least, of no benefit to the concrete.

One of the most important contrivances on a pneumatic caisson job is the air lock, without which the work cannot be carried on.

The lock is essentially an air chamber having two doors, one opening to the atmosphere and one into the working chamber or shaft. In the early caissons the lock was placed below the shaft in the working chamber, and when the material was placed in the bucket and the lock, the lower door was shut and the air allowed to escape from the lock, when the upper door was opened, allowing the material to be hoisted out. This was an inconvenient and unsafe position for the lock; in fact, it seems to be about the worst position that could have been selected, for if the caisson became too wet there would be danger of smashing the lock, and then the lock had to be taken to pieces and taken out before the shaft could be filled. The reason for putting the lock in such an awkward position was probably to permit adding to the shaft and cofferdam without removing the lock, before the idea of having an additional door at the bottom of the shaft in the air chamber occurred to caisson men. This door at the bottom of the shaft is now used when it is desired to lift the lock off temporarily to place more shafting, so as not to permit the air to escape from the working chamber during the operation. The door is also useful in case of emergency or accident.

It probably did not take long for the advantages of placing the lock on top of the shaft to become apparent. But at first the hoisting mechanism was placed inside of the lock—so the bucket would be lifted from the working chamber up into the lock, after which the bottom door would be closed and the material dumped through a side door or lifted up through a top door. Cumbersome and slow as such a method is, requiring the material to be handled twice instead of once, it is still used in Europe, but very seldom in this country.

It was long, however, before this lock was superseded by the modern locks which permit the bucket to be lowered into the air chamber, filled, taken out, emptied, and returned to the working chamber without detaching it (if desired) from the cable of the hoisting engine. The first lock to accomplish this time and money saving result had the top door in two horizontal halves, meeting over the center of the shaft, having a hole for the stuffing box about 3 or 4 inches diameter at the center of the joint between the two halves. This stuffing box was so arranged with packing, etc., that the steel cable could pass through it



GETTING READY TO ENTER THE LOCK.

freely without allowing much air to escape. The stuffing box, of course, remained on the cable near the bale of the bucket when the bucket was taken out of the lock.

It has now been almost entirely discarded, as it has been found by experiment that it is only necessary to allow a hole in the door or doors sufficiently large for the cable to pass through, and that the resulting loss of air is not sufficient to make a stuffing box (patented) necessary. As there is no object in the cable passing through the bottom door of the lock when the bottom door is shut, the best form for the lower door is a single round door slightly larger than the opening, hinged on one side and known as a flap door, as it swings up against its door seat and is held there by air pressure. A rubber gasket is usually attached to the door to prevent the air escaping between the door and its seat. The gasket is usually ½ inch thick and from 3 to 4 inches wide, in the shape of a ring, about the diameter of the opening.

Thus, in present practice, the derrick lowers the bucket into the lock when the upper doors close against the cable, and after the lock has been filled with air the bottom door is allowed to drop open of its own weight, when there is nothing in the way to prevent the bucket being lowered to the working chamber, filled with material and hoisted into the lock again. Then the lower door is swung up by levers from the outside, the air in the lock allowed to escape, permitting the top doors to be opened, etc.; and the entire cycle of filling, emptying, and returning a half yard bucket is performed twenty times an hour; a vast improvement on the old system. Numerous patents have been taken out to get around the original patent. One has a circular flap door for the top as well as bottom, the top door having a slot from the side to the center, permitting the door to shut while the bucket is suspended in the lock, an additional contrivance being required to then close or cover the slot.

Another lock, much more used, has a circular top door so placed that the edge of the door is directly over the center of the shaft, permitting the hole for the cable to be put in the side of the door instead of the center. This requires the lock tender to give the bucket or cable a slight push as the bucket enters and leaves the lock, which he easily accomplishes.

It would seem that every conceivable useful form of lock has been patented, and though there are numerous lawsuits pending, none have been settled.

All the locks described so far have doors which open in, so that when they are shut the air pressure tends to hold them shut, which is the only safe way, for the greater the air pressure the tighter the door will be shut. But to get around the original patents, locks have been built with upper doors which are held on from the outside by means of screws, etc., and when the bucket is taken out of the lock the door remains on the cable with the stuffing box, over the bale of the door. This patent was at once bought up, and as its only use would be to get around other patents, very few of the locks were ever manufactured.

In city work the material excavated from the caissons is nearly always removed by buckets through the air locks, but in big river caissons it is usually much cheaper to use "blow pipes." A "blow pipe" is simply an iron pipe, usually 5 inches diameter, from the deck of the air chamber to the surface. At the top is an elbow to deflect the material, and in the air chamber is a flexible pipe connected to the iron pipe; at the lower end of the flexible pipe is a valve. The sand or other material is shoveled up against the valve and when the valve is opened everything in front of it, even good-sized pebbles, is blown out, sometimes 100 feet or more beyond the end of the pipe. The material can be blown out so much quicker than it can be shoveled against the bottom of the pipe that the valve is necessarily kept closed much of the time.

The blow pipe is operated by simply allowing the compressed air in the working chamber to escape, carrying the material with it, the air pressure, of course, not being increased beyond the pressure required to keep the water out of the working chamber. But as a rule "blowing" is not resorted to until the pressure is about 8 or 10 pounds per square inch. The men have to be careful not to let their hands get caught, as they would have a good chance of losing them; in fact, the force is so terrific that the very hardest material is required for the upper elbows, and I have seen cast-iron elbows with metal two inches thick worn clean through in a couple of hours and less. Sometimes big blocks of oak are cut to fit over the elbow and roped on until a new elbow can be obtained.

The contractor for the first caisson for a New York skyscraper attempted to blow out the quicksand—blowing it out very wet and allowing the water with a good deal of sand to escape into the sewers. This was a very economical arrangement at first, until the sewers got "plugged" and the city put a stop to the operation.

Bucket locks are much used for concreting the working chamber as well as for excavating small caissons; but for the large caissons or where there are two shafts, a special concrete lock is used. This is usually an ordinary 3-foot shaft with a door in the bottom and a cone above the lower door. The lock is placed on top of the shaft and has a hopper arranged over it. As soon as a yard or so of concrete has been dumped into the lock, the top door is shut and the bottom door is opened, allowing the mass to fall down the shaft into the working chamber. The concrete can thus be taken in about as fast as the men below signal that they are ready for it.

Concrete should be made very wet, wherever possible, but the men in the air chamber do not like it wet at all, and they are always asking for dryer concrete. As long as the concrete is spread in approximately horizontal layers it cannot be too wet, but when it is necessary to bench it around the sides and under the roof it is impossible to use wet concrete. It is customary to fill the air chamber in horizontal layers to within about 3 feet of the roof and then bench the concrete around the sides and under the deck until there is only a space under the shaft left. The men, of course, prefer, where they can, to keep a working space about 5 feet high. The concrete is usually carried to within 3 or 4 inches of the roof, and the remaining space is then filled with mortar packed in place with a wooden rammer about 3 x 1 inches by 3 feet long, driven or pounded with an 8-pound hammer—which gives a very good job, but is, of course, very slow.

Sometimes the concrete is carried up horizontally to within 18 inches of the deck and allowed to set hard, at least 12 hours being necessary, when the air is taken off and wet concrete is dumped down the shaft. The trouble with this method is to be sure that all the spaces under the roof get filled, for no one who has not tried it would believe that the water in the

concrete could disappear so completely. I have seen a caisson with two 3-foot shafts about 6 feet center to center, where the concrete was dumped down one shaft in an absolutely "sloppy" condition, and yet when we suspended work to examine the concrete, we found that the concrete was filling the shaft it was dumped in without filling the space under the deck to the adjoining shaft. I have seen concrete dumped into a shaft so wet that one would expect to see a couple of feet of water on top of the concrete, and yet when the work was stopped the concrete looked almost dry.

If mortar is to be made watertight the proportion should never be poorer than one volume of cement to two volumes sand, to insure filling all the voids in the sand. For the same reason the proportion of cement and sand should be the same for concrete where as much stone can be used as can be covered, depending on the smallness of the stone or gravel and the wetness of the mass; much more stone can be used if the stones are small and the mass wet. I have made caissons watertight against a head of 80 feet of water by concreting to about 6 inches above the cutting edge and then placing a layer of mortar about 2 inches thick and covering this at once with good wet concrete, 1—2—4. And yet many say that it is impossible to make concrete hold water—which, however, is certainly true as far as "dry" concrete is concerned, that is, concrete that requires ramming to bring the moisture to the surface.

The concrete in the cofferdam above the deck should also be put in very wet, and though it is very customary to use a 1—3—5 concrete for this purpose, I would much prefer a 1—2—4 mixture, though the amount of stone could be increased as stated above if judgment is used.

Great care should always be exercised when pumping is necessary to avoid pumping the cement out of the concrete and thus ruining the mass. I have heard a contractor brag of using eight big pumps, with 6-inch, 8-inch, and 10-inch discharge pipes, on an open cofferdam 30 x 50 feet, while concreting. Small wonder he had not much confidence in concrete after such abuse.

The amount of concrete placed on the deck of the caisson while sinking often depends on the amount of weight required for the penetration. On shore, for instance, the friction on the sides starts at the surface and the concrete on the deck has to be kept above the surface of the ground until all the concrete is in that will be required for the finished structure, when pig iron or other temporary weight has to be added. But in river work, where the water is often from 20 to 40 feet deep to start with, the caisson would be too heavy if the concrete were kept up to the surface of the water; in fact, sometimes the level of the concrete in the cofferdam of the caisson is as much as 30 feet lower than the surface of the water, which requires very heavy cofferdam bracing and makes any leak in the cofferdam or deck of the caisson very troublesome and dangerous on account of the great head.

(To be continued.)

THE FLAMING ARC LAMP.

ITS PRESENT STATUS.

BY ALFRED A. WOHLAUER.

THE flaming arc lamp has gained supremacy for certain uses in Germany over all other types of arc lamps, and promises soon to become a great factor in this country, particularly when the manufacture of its special electrodes is seriously taken up by American manufacturers. At first the new type was handi-

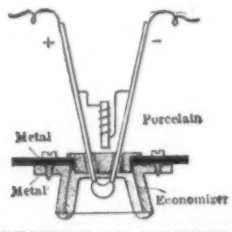


FIG. 1.—PRINCIPLE OF BREMER FLAMING ARC LAMP.

capped in competition with the inclosed arc on account of the shorter life of the electrodes, and also with respect to interior lighting, by the fumes given off. Nevertheless of late it has become recognized that the flaming arc lamp is without rival for many uses, especially for advertising purposes and numerous other cases of outdoor lighting, owing to its very high efficiency and its superior light qualities, the "cheerfully brilliant" yellow tint being more agreeable to the eye than the violet hue of the inclosed arc lamp.

The first commercial yellow arc lamp was placed on the market by H. Bremer in 1899. As in the case of all important inventions, the flaming arc lamp, however, had predecessors and a more or less gradual development. As early as 1844 Casselman suggested the mixture of salts of strontium, copper, zinc, etc., with the carbon of electrodes; his work was continued by others and considerable investigations along similar lines were carried on, especially by Carré and Archereau in France.

PRINCIPLES OF THE FLAMING ARC LAMP.

Fig. 1 shows the principle of Bremer's first success-

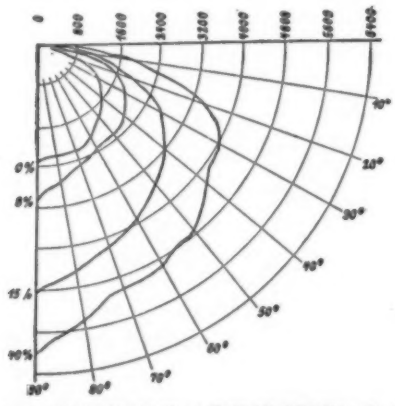


FIG. 2.—INFLUENCE OF PERCENTAGE OF FLUORSPAR UPON YIELD OF LIGHT.

ful lamp and represents at the same time the typical arrangement of the flaming arc lamp, the special feature of which is the use of a special flaming carbon in an inclined position. There are, it is true, other arc lamps in which flaming carbons are employed in a vertically superposed position, often called luminous arc lamps; to this class belong the magnetic lamp, titanium carbide lamp, Blondel lamp, and others, which will not be discussed here. It is also beyond the scope of this article to treat of lamps, such as the Carbone and its derivatives, having also inclined carbons, but not impregnated with metallic salts.

Flaming arc electrodes consist of carbons to which mineral substances are added, mostly fluorides of alkaline earths, which permit the arc or vapor path to be drawn out to great length and at the same time rendered luminous, whereby the light intensity is considerably increased. While the common and especially the inclosed arc owes 95 per cent of its light to the incandescent crater of the upper carbon, 25 to 35 per cent of the light emitted by the flaming arc is due to the luminous vapor path.

The inclined position of the carbon suggested itself to Bremer owing to the formation of a kind of a slag due to mineral admixtures which, being non-conductive, render the arc unsteady or even extinguish it, or interfere with starting. Although by the addition of waterglass, boracic acid, etc., Bremer reduced the bad effects of the slag, the most efficient means to overcome the trouble consists in placing the carbons in an inclined convergent position, so that no slag can form in the vapor path. Moreover, this arrangement offers another advantage in that nothing remains to obstruct the light of the arc, thereby resulting in an additional increase of light.

Two more elements were added by Bremer to his well-known combination of a flaming arc lamp, namely, the "economizer" and the "blow-magnet." The "economizer," indicated in Fig. 1, consists in its original form of a truncated metallic cone, framing and supporting a porcelain disk through which the carbons are inserted. Closely surrounding the flaming arc, it augments its efficiency by concentration of the heat, and increases the life of the carbons by limiting the air supply. Moreover, being covered with white deposit from the arc flame, it acts as an excellent reflector, throwing practically all the light of the arc into the lower hemisphere.

In order to prevent the arc from climbing up and from destroying the "economizer," especially when the carbons are almost burned out, a blow-magnet is provided by means of which the arc is blown away from the "economizer" or even extinguished if necessary. The blow-magnet can furthermore be used to spread out the arc into the shape of a reversed umbrella and thereby increase its area. As a consequence, it is possible to increase the diameter of the carbons and thus lengthen the intervals between trimming. The electric arc, however, is itself the seat of a magnetic field which tends to drive the arc away from the tips, so that under some circumstances a blow-magnet is not required. In fact, for very high currents above 12 amperes it might be necessary to produce an opposite effect, the blow-magnet drawing back the arc toward the carbon tips instead of blowing it away from them.

FLAMING CARBONS.

Bremer's original flaming carbons were thoroughly mixed or impregnated with compounds of calcium, strontium, magnesium, etc., with the addition of boracic acid. According to Bremer, the efficiency of light production increases with the percentage of salts added to the carbons, and investigations carried on by Prof. W. Wedding proved this fact, but showed also that the light intensity does not increase rapidly with increase of salt mixture above about 15 per cent. This is apparent from Fig. 2, which shows the light distribution with electrodes containing varying percentages of fluorspar; in Table I and in Fig. 3 the influence of the percentage of fluorspar upon the mean spherical candle-power, as well as upon the specific

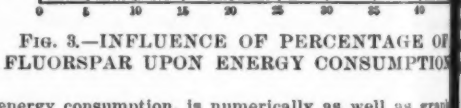


FIG. 3.—INFLUENCE OF PERCENTAGE OF FLUORSPAR UPON ENERGY CONSUMPTION.

energy consumption, is numerically as well as graphically illustrated. It will be seen that the yield of light does not increase markedly above 20 per cent admixture, and as the amount of slag increases with the quantity of the salts and the arc also becomes more unsteady, present-day flaming carbons do not contain more than 15 per cent admixture, and, moreover, the salts are only added to the core, the remainder of the electrode consisting of pure carbon. The formation of slag is perfectly *nil* for these carbons although the yield of light is smaller than it was for the original carbons containing a greater amount of salts.

The color of the flaming arc lamps is yellow when the electrodes are impregnated with calcium fluoride. By changing, however, the impregnating material, the color can be varied over a wide range. Three kinds of flaming carbons are now on the market—yellow, pearl white, and red. Calcium salts produce the yellow, strontium the red (which is, as a rule, rather very light pink), and barium salts the white color. The most popular of course is the yellow carbon, the more so for the reason that it gives the high

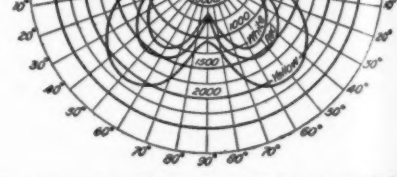


FIG. 4.—INFLUENCE OF COLOR OF FLAME UPON YIELD OF LIGHT.

efficiency. The yield of light from the white flame carbon is only little more than from open arc with pure carbons, while the red carbon stands between. An approximate idea of the change of the efficiency with the color can be gained from Fig. 4 extracted from a recent paper by Mr. S. H. Blake.

* Electrical World.

In order to increase the steadiness of the rather long flaming arc, it is necessary to keep the diameter of the carbons at a comparatively low figure, whereby, of course, their life is reduced. The only direct means of increasing the life of the carbons is offered by an increase of their length (see Table II, first two columns). The resistance of the flaming carbons is therefore considerably higher than that of the old

away to cause a change of resistance sufficient to weaken the magnet operating the clutch, which then releases the carbons (Fig. 7). In another very recent mechanism of this order, the feed is limited by a friction brake acting upon a screw which otherwise would rotate under the influence of the weight of the downward feeding carbons.

The hot-air lamp employs the expansion and con-

the case of street lighting where the lamps are placed at considerable distances apart, and it would be much better if the light just beneath the lamp would have minimum intensity, increasing with the angle from the vertical. The fact that the illumination below the lamp is maximum is not only due to the light emitted from the luminous vapor path, but to a much greater extent to the light from the incandescent carbon tips.

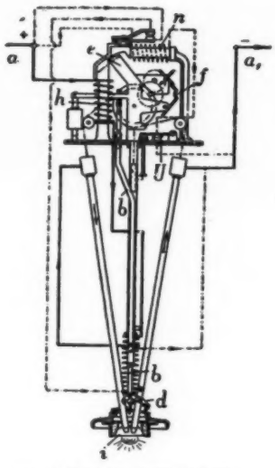


FIG. 5—CLOCK MECHANISM.

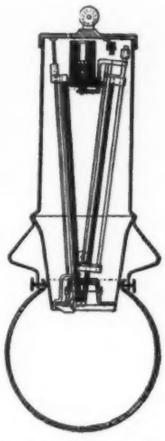


FIG. 6—BECK LAMP.

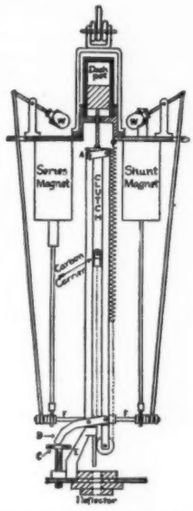


FIG. 7.—CLUTCH MECHANISM.

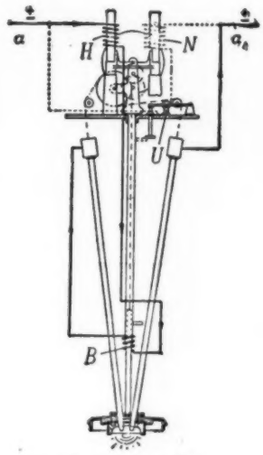


FIG. 8.—MOTOR LAMP.

SOME TYPES OF FLAMING ARC LAMPS.

carbons, for this reason and because the impregnating salts are rather poor conductors for the electric current, especially in a cold state. To remedy this, some electrodes contain a metallic vein or an electrolytic deposit of copper along the surface.

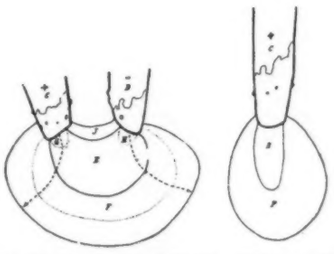
MECHANICAL FEATURES.

The question of mechanical construction is one of great importance to the flaming arc lamp, and while almost all flaming arc lamps are similar in the features illustrated in Fig. 1, the mechanical construction, especially of the regulating and feeding mechanism, differs considerably. At the present time we can distinguish five main types, all of which have found their field and have their merits and demerits. These may be classified as follows:

1. Clock mechanism.
2. Gravity feed mechanism.
3. Clutch mechanism.
4. Hot wire mechanism.
5. Motor mechanism.

The clock mechanism is identical with the clock mechanism of the old type of arc lamps. It consists of a frame (*e*, Figs. 5 and 9) which is actuated by a differential system consisting of a series (*h*) and a shunt (*n*) electromagnet. Under the influence of the shunt magnet, the frame releases a detent (*f*), which causes the carbons to feed down. When the carbons come in contact, a current flowing through the series coil lifts them up again, thereby striking the arc, which by the combined action of the series and shunt magnet is kept at its proper length.

An interesting type of gravity feed flaming arc lamp was devised by Beck which by its simplicity admits of a very reliable construction. It does not employ any electrical or mechanical mechanism for feeding and regulation since the carbons slide down into proper position by their own weight. They are prevented from sliding too far by a kind of a rib (*b*, Fig. 11) which protrudes from one of the carbons and rests on a little support attached to the "econo-



FIGS. 12 AND 13.—SHOWING ASYMMETRY OF FLAMING ARC.

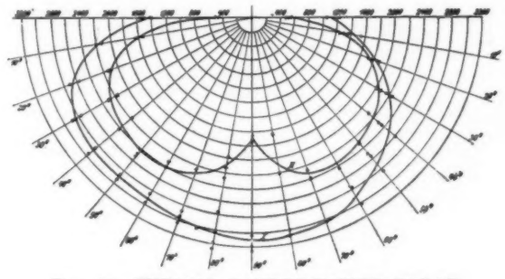
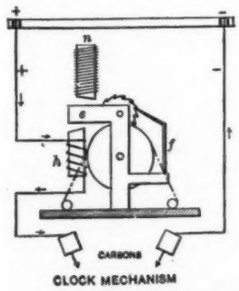
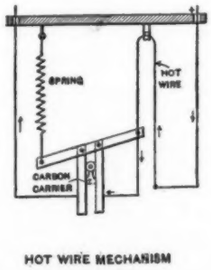


FIG. 14.—TYPICAL CANDLE-POWER POLAR CURVE OF FLAMING ARC LAMP.



CLOCK MECHANISM



HOT WIRE MECHANISM

FIGS. 9 AND 10.—LAMP MECHANISMS.

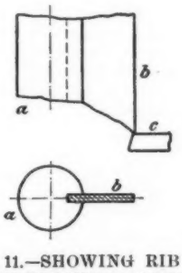


FIG. 11.—SHOWING RIB OF BECK FLAMING CARBON.

izer." Fig. 6 shows the mechanical connection between the two carbons and a small electromagnet which operates the carbon not supported in order to strike the arc.

The clutch mechanism also employs the gravity feed. The carbons are prevented from sliding too far by a clutch which grasps the carbon holder at the proper time, holding it until enough of the carbon is burned

traction of a wire for the regulation of the arc. The hot wire is balanced against a spring which, in the case of expansion of the wire, contracts, or *vice versa*, and transfers its motion to the carbons, for regulating purposes (Fig. 10). The action is rather slow, but seems to give satisfactory results. The lamp can be operated on direct current as well as on alternating current, the arc being as a rule in series with the hot wire.

The motor lamp for alternating current contains, as illustrated in Fig. 9, a metallic disk which is influenced by a differential magnet system, which produces a torque on the disk in either one or the other direction, or keeps at a standstill just as the series or the shunt coil preponderates or both are balanced against each other.

ILLUMINATING FEATURES.

It has been mentioned above that the flaming arc lamp is superior to all other arc lamps as to light efficiency. The specific energy consumption per mean spherical candle-power averages about 0.5 watt per candle-power, which is from four to six times better than the efficiency of the inclosed arc lamp and almost three times better than that of the tungsten lamp.

While arc lamps with vertically superposed carbons produce the maximum light intensity at an angle of 45 deg. below the horizontal, lamps with inclined carbons give their maximum light intensity exactly below the center of the lamp. This is not very fortunate in

It is erroneous to assume that all the light of the flaming arc lamps emanates from the luminous vapor, for, as has been demonstrated by Prof. Wedding, only about one-fourth of the light of the arc is emitted by the arc flame, while three-quarters is produced by the incandescent carbons. The effect of a maximum light intensity just below the lamp is somewhat modified by the ash receiver, which is just under the lamp and obstructs the light emitted in that direction.

Curve I of Fig. 14 is a typical candle-power curve of the flaming arc lamp, while curve II shows the light distribution with globe and ash receiver. These curves are taken in a vertical plane through the axis of the two carbons. It must be borne in mind that the flaming arc is not a symmetrical source of light, for, owing to the arrangement of the carbons side by side, the extension of the arc is greater in a plane through the two centers of the carbons than in a plane at right angles thereto. This can be seen from Figs. 12 and 13, which show the approximate shape of an arc and illustrate its unsymmetry. The unsymmetrical appearance of the arc is, however, modified and equalized in practice by the globe which surrounds the arc.

ECONOMY.

It has been pointed out above that the yield of light of the flaming arc lamp increases with the percentage of salts added to the carbons. As indicated in Table I, the specific energy consumption per mean spherical candle-power is 0.34 for a percentage of 40 per cent of fluorspar, but, on account of the large amount of slag formed, such a high percentage of admixture does not seem practical and economical.

TABLE I.

Influence of Admixtures of Metallic Salts to Flaming Carbons upon Light Intensity.

Percentage of fluorspar. Per cent.	Mean spherical candle-power. L_s	Specific energy consumption, S_s
0	490	1.0
8	710	.7
15	1,050	.475
20	1,160	.43
25	1,350	.37
30	1,380	.36
35	1,400	.35
40	1,480	.34

This table is based upon results of experiments made

by Prof. W. Wedding. The values of the mean spherical candle-power are given in English candles and refer to lamps with an opal globe. The specific energy consumption is calculated for a total energy consumption of 550 watts across the terminals of the lamps and not merely across the arc.

Another factor to be considered in connection with the economy of the flaming arc lamp is the size, diameter, and length of the carbons. The diameter of the carbons depends on the construction and type of lamp and is influenced by the blow-magnet and "economizer" and other arrangements. Nevertheless, the diameter has to be kept within certain limits, in order to prevent the arc from climbing. It is therefore the length

TABLE II.

Influence of Carbon Dimensions upon Economy of the Flaming Arc Lamps.

Ten-ampere, 55-volt, 550-watt lamp. Mean spherical candle-power, 1,120 candles. Consumption, 0.5 watt per mean spherical candle-power. Diameter of carbon 5/16 to ⅜ inch. P = price for carbons and trimming per trim. C = renewal cost per kilo-candle power.

				Rates per kw-hour.				
Length.	l.	P.	Cr.	2.	4.	6.	8.	10.
12	7	16c.	2.05	3.05	4.05	6.05	7.08	8.05
15¾	10	18c.	1.6	2.6	3.6	4.6	5.6	7.6
20	14	21c.	1.35	2.35	3.35	4.35	5.35	6.35
23½	17	23c.	1.2	2.2	3.2	4.2	5.2	6.2

of the carbons which mostly influences their life and therefore the economy of the arc. An increase of the length of the carbons increases their life and therefore

TABLE III.

Economy of Flaming Arc Lamp for Various Currents.

							Rates per kw-hour.					
A.	V.	Watts.	Ls.	Ss.	P.	l.	Cr.	2.	4.	6.	8.	10.
6	55	330	480	.68	13.5	10	2.8	4.2	5.6	7.0	8.4	9.8
8	55	440	800	.55	15	10	1.9	3.0	4.1	5.2	6.3	7.4
10	55	550	1,100	.5	18	10	1.6	2.6	3.6	4.6	5.6	6.6
12	55	660	1,300	.5	19	10	1.5	2.5	3.5	4.5	5.5	6.5
15	55	825	1,700	.49	22	10	1.3	2.3	3.3	4.3	5.3	6.3
20	55	1,100	2,250	.48	25	10	1.1	2.0	2.9	3.9	4.9	5.9

reduces the expense from trimming. Table II shows to what an extent the cost of the kilo-candle hour of the flaming arc lamp is influenced by the length of the carbons for different rates for power. The table is self-explanatory, indicating that for very low power rates it is advisable to use carbons of the greatest possible length.

The size of the flaming arc lamp has also some influence on the economy. In most cases it is better economy to employ a large unit instead of using a number of smaller ones, not only on account of the higher initial cost, but also in view of decreased operating expense. This is evident from Table III, which requires no further explanation.

CONCLUSION.

The economical and practical advantages of the flaming arc lamp can be summed up as follows:

The disadvantages are frequent trimming, high price of carbon, fumes, deposits inside the lamp, and unfavorable light distribution for street lighting. All these disadvantages, however, appear to be compensated for by the extremely high efficiency, which insures a much better economy than can be obtained with any other illuminant on the market.

In the tables given, the abbreviations or symbols designate the following:

A = amperes.
V = volts.
W = watts.
Ls = mean spherical candle-power.
Ss = specific energy consumption per mean spherical candle-power.
P = price for renewal carbons.
l = life of carbons.
Cr = renewal and maintenance cost.

THE TANTALUM DETECTOR FOR WIRELESS SIGNALING.

DURING the past year or two innumerable detectors for electric waves, acting on the imperfect-contact principle, have been devised. Many of these have not been self-decohering, but occasionally a combination of metals or of a metal and some other conducting body is found which is self-restoring. Usually detectors of the latter type employ a compound of metal, such as a carbide. The arrangements using metal on metal generally call for a mechanical arrangement for restoring the high resistance of the receptive condition. An interesting detector of this type was invented a year or so ago, and used in the Lodge-Muirhead system. This device was formed by rotating a small metallic wheel, the lower surface of which just grazed a surface of mercury covered with a thin film of oil. The rotation of the wheel served to restore the high resistance of the device, which apparently was due to a very thin film of oil adhering to the surface of the disk. This film appears to be so thin that it is punctured by the potentials produced when an electric wave is received by the antenna.

A wave detector has recently made its appearance which employs mercury as one of the contacts and a tantalum wire as the other. The wire is exceedingly fine, being only about 0.05 millimeter in diameter; in fact, it is nothing more than a short piece of filament taken from one of the ordinary tantalum lamps. Tantalum is not wetted by mercury, and when this fine wire is just in contact with a mercury surface the contact resistance is from 1,000 to 2,000 ohms. This resistance is not high compared with the receptive resistance of certain other receivers, but when an oscillation is received the resistance drops to about one-eighth of its original value. This ratio can even be increased if desired and the great change gives rise to very loud signals. The inventor of the detector, Mr. L. H. Walter, says that in this respect his detector is superior to most others, although it is not so sensitive as some other types for very weak oscillations. This characteristic he thinks makes the detector particularly suitable for wireless telegraphy, since the oscillation currents used in that system of communication must necessarily be relatively powerful.

Finding the combination of tantalum and mercury so excellent, Mr. Walter tried various other combinations of metals, both with mercury and with other metals; none of them, however, compared with the tantalum-mercury couple. He did find one combination of solid metals, namely, tantalum and oxidized iron, which gave fairly satisfactory results. Such an arrangement would be well adapted for use on shipboard, where the vibration of the mercury surface of the other detectors would render them useless. However, the inventor has devised an arrangement of his mercury-tantalum detector in which the tantalum wire is in contact with a small globule of mercury entirely inclosed, and which therefore does not vibrate.

It is an interesting question as to what gives rise to this high resistance of contact. One would at first attribute it to a thin film of oxide, similar though not so strong dielectrically as the coating of oxide which forms on the aluminium plates used in electrolytic rectifiers or condensers. Such a film might be easily formed if the tantalum and mercury were momentarily separated, but when the surface of contact is entirely below the upper surface of mercury, one would hardly expect such a coating of oxide to repair itself after puncture. Another explanation might be that a thin film of air adhered to the mercury. This would prevent the latter from wetting the tantalum, but the same difficulty of explaining the self-restoring effect is met. If this thin film of air behaved as a liquid, it might be said that its surface tension repaired the break; possibly there is some such effect.—Electrical Review (New York).

THE POWER MEASUREMENT OF ENGINES.

AT the summer meeting of the American Society of Mechanical Engineers there was read a paper by Prof. L. S. Marks which expounded a new view of the power of steam and other vapor engines. It is proposed to call the new measurement of power the "total power." Prof. Marks suggests that the difference between it and the indicated power, as ordinarily reckoned, is not of great practical importance in modern steam engines, but is generally large in gas and oil engines. If the fairly accurate measurement of "total power" be practicable, we venture to say that the distinction is of practical commercial consequence in all classes of engine, while from the scientific point of view it is quite essential. The difference between total and indicated power has, however, never been overlooked in any really scientific exposition of engine action, although it may not be found insisted on in popular treatises such as satisfy most college examiners and the students who grind only for examination passes.

It is a quite commonly known fact that the top admission line of an indicator card falls well below the boiler pressure, and it is a not uncommon practice to rule in a line showing the boiler pressure and the loss between it and the pressure of admission into the cylinder. A similar difference in height between the exhaust line on the indicator card and the real exhaust pressure in the condenser or the atmosphere is well recognized. The two areas thus lost at the top and bottom of the card measure power actually exerted by the "working substance," but possibly wasted in overcoming injurious mechanical resistances. These resistances are of various kinds, and it is unnecessary to detail them here. The main point is that essentially they ought to be classified along with those other resistances, such as piston and stuffing-box, and crosshead and bearing friction, which result in a difference between indicated and brake horse-power. All these are equally, no more and no less, injurious and waste expenditures of the mechanical power actually developed by the working substance. This actual or "total" power developed is the brake power plus all these wastes; it is the indicated power plus such of these wastes as occur before the working substance acts upon the piston. So far as concerns the thermodynamic efficiency of the power-developing process to which this substance is subjected, Prof. L. S. Marks points out that the only just comparison must be made with this "total," and not, as is usual, with the indicated power. The real thermodynamic efficiency of the working fluid is therefore higher than it is usually stated to be.

The items of waste work, which are mainly due to friction and irrecoverable acceleration of momentum, require to be very carefully distinguished from those done upon the working substance in such a manner as to increase its recoverable energy. Such work is done by every kind of feed pump, the water feed to the steam boiler, the feed of air and gas on the charging strokes of the gas engine, the feed of oil and air to every form of oil engine, alike when this work is done in a separate pump barrel and when it is done in the main working cylinder.

In the steam engine this feed work is of so small amount as to be of little practical consequence, the power spent on the feed pumps being mostly wasted on frictional pump resistance. But in gas and oil engines it forms a large fraction of the total action involved, and Prof. Marks points out that the usual process of subtracting the area of the "negative loop" from that of the "positive loop" of the gas engine indicator diagram involves a somewhat serious misinterpretation of the meaning of the diagram, which results in crediting the engine with less than its just thermodynamic efficiency. These negative feed-pump areas in the complete indicated power are quite properly subtracted in order to arrive at the "total power" giving the real thermodynamic efficiency; whereas the waste frictional and inertia areas —which do not appear on the indicator card—are, on the contrary, to be added.

While it is easy fully to grant the justice of the argument for this new measure of total power and new reckoning of thermodynamic efficiency, it may be pointed out that it will be seldom easy to apply the new measure correctly. Take, for instance, the drop between boiler pressure and the cylinder admission line. The whole of this is not due to mechanical waste arising from frictional and inertia resistance to the steam flow; part of it is due to the cooling effects of the transmission pipes, the valve chest, the steam ports, and the cylinder walls. It is true that these cooling effects appear more in the form of contraction of volume than in drop of pressure; but the area of the indicator is the product equally of volume and of pressure. Especially along the expansion curve is it extremely difficult to differentiate accurately between waste drop of pressure and waste loss of volume. To do so would require more exact means of measuring weight of feed water and degree of wetness of generated steam than we can at present use in non-laboratory boiler tests. Again, during exhaust, the indicator card pressure is raised and volume increased by conductive receipt of heat from cylinder walls.

These two opposite kinds of heat waste clearly ought to be debited against the thermodynamic efficiency. They are of very much greater amount, and are much more difficult to measure, or even to estimate, in gas and oil engines than in steam engines. The practical importance of separately measuring the thermodynamic and the purely mechanical efficiencies of power engines cannot be doubted. The object of ascertaining efficiency is to guide and promote efforts to reduce inefficiency; and the methods to be pursued in lessening thermodynamic and in lessening mechanical waste losses are as different as any two sets of processes could be. It is to be hoped that the subject may be further pursued, and that means of more thorough analysis of the wastes in all kinds of engine may be discovered in easily applicable forms. It is quite necessary to remember that some of the waste that occurs before the indicator card is taken, that is, before the working substance reaches the piston and works upon the piston, is mechanical waste; it is equally necessary to remember that some of the waste occurring after the taking of the indicator card is heat waste.—The Engineer.

The following figures show the mileage of steam and electric railroads in operation in California, together with the mileage completed in 1907, and the steam and electric lines projected: Steam railroads in California, 6,700; electric lines in California, 1,500; steam railroads completed in 1907, 490; projected, 1,400; electric lines projected, 700. The Tonopah and Tidewater line, starting from Ludlow, on the Santa Fé line, and running northward past Death Valley and into Nevada's mining camps, stands first in construction, with 138 miles of line added in 1907. The Western Pacific Railroad is second with 119 miles, in three sections, along its route from San Francisco to Beckwith Pass on the Nevada border. The company now has no difficulty in securing men. When this line is finished it will add another transcontinental line from the Atlantic to the Pacific. The Southern Pacific Company has added 107 miles to its system in various parts of the State.

WHAT IS THE CARNOT CYCLE?

SOME PRINCIPLES OF STEAM ENGINEERING.

At the middle of the last century the steam engine had attained to a high degree of perfection. Its development was, it is true, incomplete, but it had been successfully applied to all the great duties of the mine, the waterworks, the factory, the railway, and the steamship. The engines were mechanically excellent; the fuel economy was good, and they were built in units of thousands of horse-power. Steam power, in fact, was revolutionizing the whole of the social and industrial conditions of the globe. Notwithstanding this great material and engineering success, the world was in complete darkness as to the connection between steam motive power and heat. It was seen that motive power of almost any magnitude could be obtained by the agency of heat; but how it was obtained and how much power was connected with a given quantity of heat was quite unknown. The fuel consumptions of existing engines were known, and certain modes of improving economy were evident, and engineers were busily engaged in testing these modes by the slow but sure methods of invention, design, construction, and operation in practical work; but in this they had but little aid from pure science. The science of thermo-dynamics did not yet exist. New light was dawning, however, which gradually illumined the whole world of pure science and engineering practice. Men of the first rank in intellect—Newton, Cavendish, Rumford, Young, and Davy—had long before expressed the opinion that heat was not material in its nature, but was a mode of motion; but their opinions, although to some extent supported by experiment, made little impression upon the scientific world, and in 1850 we still find the most distinguished physicists adhering to the "caloric" or material theory of heat.

The great change, from the errors of the old theories to the truth of the new, was due to the work of Joule, Thomson, and Rankine in Great Britain, and of Carnot, Meyer, Clausius, Helmholtz, and Hirn on the Continent. The story begins with the work of Carnot in 1824, who published in Paris in that year a pamphlet entitled "Reflections upon the Motive Power of Heat." He was attracted by the problem of the steam engine and the air engine. He saw that heat and motive power were connected in some manner, and he endeavored to settle in a quantitative way the limits of that connection by the invention of an ideal series of operations by means of which the greatest conceivable amount of mechanical power may be obtained from a given quantity of heat under given circumstances. For the purpose of his demonstration he assumes only two things: (1) That if heat be added to any body under standard conditions of temperature, pressure, and volume, and the body be carried through any series of mechanical processes, returning ultimately to the standard condition of temperature, pressure, and volume, then the quantity of heat added to the body is the same as that which has been discharged from it; (2) no process can exist whereby a given mechanical energy can increase its own quantity. On these indisputable assumptions he bases his ideal cycle, which consists of four simple and easily imagined operations, occurring within a cylinder behind a piston, so arranged that during the cycle work can be done by the working fluid upon the piston or work done by the piston on the working fluid.

First operation.—The given volume of the working fluid is to be imagined as confined at its highest temperature and pressure behind the piston, and heat is to be added to keep the temperature constant, while the fluid expands, moving the piston and doing work upon it.

Second operation.—The supply of heat is cut off, and the working fluid expands also during work on the piston, while its temperature falls to the lowest point and its volume increases to its maximum.

Third operation.—The piston returns, compressing the working fluid, but allowing the heat of compression to escape, so that the temperature remains during the operation at its lowest point.

Fourth operation.—The piston compresses the working fluid, without allowing any loss of heat, to such an extent that the temperature rises again to its highest point, and the working fluid exists at the end of this operation at the same volume, pressure, and temperature as at the beginning.

This assumed series of operations would give a certain available work area, the indicated power of the engine, inasmuch as the work done by the working fluid would be greater than that done upon it. If however, it be assumed that in all the operations the direction of motion of the piston be reversed, then compression without loss of heat would take place in the second operation; further compression, but with sufficient heat loss to keep temperature constant, would occur on the first operation; the fourth operation would follow with expansion, and the third operation would conclude also with expansion. The engine would be reversed by beginning with the second operation, moving the piston backward in the order second, first, fourth, third. Carnot shows that this reverse operation would be performed by exactly the same amount of work as was given out by the direct operation, and that an amount of heat would be returned at the higher temperature equal to that which was added in the first case.

An engine which fulfills these conditions, Carnot states, will give the greatest amount of work which can be obtained from a given quantity of heat falling through a given temperature range. And it is evident that this must be so, because, if we assume the existence of any engine under the same conditions giving a greater amount of work from the same heat, then that engine could drive a Carnot engine in the reverse direction in such proportion as to return to the higher temperature a greater amount of heat than it abstracted, and so mechanical energy could be obtained without any heat fall whatever. This marvelous demonstration is obviously independent of the nature of the working fluid; it applies equally to all working substances, whether solid, liquid, or gaseous, whether physical state changes or not. It at once gives a standard of the limit of mechanical power which could possibly be obtained from a given amount of heat and a given temperature fall.

The Carnot cycle operations, as here given, are applicable either to the material or to the dynamical theory of heat; but Carnot originally stated that the whole of the heat added in the first operation was to be discharged in the third. Under the material or caloric theory, work was supposed to be done by the fact of fall in temperature. Naturally, as the heat was material it could not be destroyed or changed into mechanical energy. The production of mechanical energy was supposed to be incidental to the fall of temperature, much in the same way as mechanical energy was produced by the fall of water-level, and this analogy is used throughout Carnot's work of 1824. Carnot thus succeeded in proposing a standard of efficiency which was applicable to any heat engine, whatever the working fluid and whatever the operative cycle. By his method a limit could be set, fixing the maximum of mechanical energy to be obtained from a given heat quantity and a given temperature range. To reduce this to numerical values it was necessary, however, to experiment on any one working fluid within the desired temperature range in order to determine the work area in its relation to heat quantity and temperature fall. Carnot's writings show that he intended to make such observations, and, had he succeeded, thermodynamics would have become a science at an early date. Carnot's death, however, in 1832, at the sadly early age of thirty-six years, prevented this development.—From a paper read by Dugald Clerk before the Engineering Section of the British Association for the Advancement of Science.

THE DEVELOPMENT OF INVENTION.

Rumor has it that Mr. Parsons's late partners, though expert engineers, tried to dissuade him from further pursuing the development of his invention by assuring him that he would never make a copper penny out of his steam turbine. Bessemer, again, had to show the expert steel makers how to work his invention, and Siemens had the same experience with the "open hearth." The now almost universal system of electrical distribution, by means of transformers, received a very cold welcome from the leading electrical engineers of the day, when first introduced by Messrs. Gaulard and Gibbs. In fact, while expert opinion on minor improvements along established lines is almost invariably correct, it has often been singularly slow to accept really fundamental changes in established practice. This conservatism is by no means surprising. Ninety-nine times out of one hundred a suggested change of this far-reaching character will be found to result in failure. In general, progress is made step by step, and not by sudden bounds, and when a gigantic stride is necessary, as, for instance, from a cable crossing a channel to one spanning the Atlantic, the weight of authority will generally be in favor of an extension of methods proved successful in the smaller field, and against the introduction of such innovations as ultimately proved necessary in the case in point.

Of course, in this case it may be claimed that the authorities implicated were not actually experts, and that the young physicist, who here showed the way to telegraph engineers, was really the only one concerned. But in nine cases out of ten the engineer's opinion in a matter of applied science will be sounder than that of the exponent of "raw science," as Mr. Swinburne has aptly called the science of the laboratory. From a commercial standpoint the laboratory solution of a practical problem is generally no solution at all, but rather an indication that a solution is possible. Faraday undoubtedly laid the foundation on which is based the design of the modern highly efficient electric generator, but the passage from his observations to the construction of the Gramme machine, which may, perhaps, be considered the immediate progenitor of the modern dynamo, involved an expenditure of a vastly greater amount of money, and probably more hard thinking, than was expended in the original investigation, while requiring infinitely more pluck and enterprise. Unless we mistake, not a few physicists regard with some envy the large rewards at times reaped by the successful engineer or business man, and this jealousy is occasionally manifested in a somewhat peculiar fashion. We have known not long since a mathematical physicist of some standing refuse to publish his views on entropy, on the ground that practical men were, in his opinion, always trying to pick the brains of the scientist, for what he considered a very inadequate remuneration, quite failing to realize that an abstract discussion of the kind in question was matter of interest rather than utility to the engineer. The latter can still use the Theta-Phi diagram without requiring to know very much of the principles on which it is based, just as a schoolboy can be taught to use a slide-rule without understanding anything as to the nature of logarithms. In fact, up till very recent times, the Theta-Phi diagram—though it must be about forty years since it was first devised by Willard Gibbs—was itself merely of academic interest to the engineer, and has only within the last ten years or so proved itself of value in the drawing-office, as opposed to the class-room.

Unquestionably the labors of the physicist in their ultimate issue may be of immense utilitarian value. They constitute, however, a bill drawn on futurity, and are thus subject to a very heavy discount as regards their present value, since in general a long period must elapse before they pass from the category of the merely interesting to the positively useful.

In this transition the influence of so-called experts might actually bar progress by the mere weight of authority, and though no doubt they would nip in the bud many of the wild-cat notions of sanguine but inadequately equipped inventors, there is no certainty that they would recognize the true line of advance when found. It cannot be forgotten, for example, that the existence of electric waves, on which is based the practice of wireless telegraphy, was recognized by the late Prof. Hughes in 1879-80, but his progress was checked by the opinion of Sir Gabriel Stokes, legitimately considered as authority, that all the effects observed were explainable on the ordinary theories of electro-magnetic induction. In short, there seems no prospect that the loss of efficiency naturally resulting from the crushing of individualism can be compensated for by establishing the rule of the so-called expert, and, moreover, the problem of selecting the latter in the changed conditions of society contemplated would itself be a problem of no little difficulty.—Engineering.

The Vulcan shipyards at Stettin are building at the present time two boats which will be used for ferrying trains across the Baltic between the German port of Sassnitz and the Swedish port of Trelleborg. These boats will have a length over all of 361 feet, with a railroad platform of 262 feet, beam 51 feet, and 16 feet draft. They are designed for the transportation of eight passenger cars or sixteen to eighteen freight cars on each trip, on the two tracks upon the platform, at an average speed of sixteen knots an hour. Their engines will develop about 5,000 horse-power with 135 revolutions. The steamers will be fitted out with luxurious staterooms for the accommodation of seventy first-class passengers, as well as with saloon, dining, smoking, music rooms, etc., and also with sleeping quarters for forty third-class passengers, and separate quarters for the accommodation of the crew. On the two bridges, one fore and one aft, will be powerful electric searchlights, to be used at night time; the boats will be supplied with two rudders, one on each end and with submarine acoustic signals. They will be launched in 1909.

SCIENCE NOTES.

By an order of President Roosevelt about seventy thousand acres of land adjoining the Oregon-California line is to be set aside as a reservation for the propagation and protection of native birds. The order includes land not suitable for agricultural purposes. The tract is probably the greatest breeding ground in the world for water fowl.

Muntz and Laine, after a profound study of the possibilities of obtaining nitrates from peat, have reached the following conclusions: Peat is a very valuable source of nitrogen. It may be employed either in the formation of niter beds or in the production of ammonia by more rapid processes. From a peat bog of 2,500 acres, with an average depth of 6½ feet and an average nitrogen content of 2 per cent, it is possible to produce 800,000 or 900,000 tons of sodium nitrate. The peat deposits of France therefore would furnish 300 or 400 times the above quantity—a total which largely exceeds the aggregate of the known nitrate deposits of Chile, including the amount already extracted from them. If these conclusions are justified no alarm need be felt concerning the probable exhaustion of the Chilean nitrate beds, in the more or less remote future.

It is generally admitted that summer squalls, which manifest themselves suddenly in clear weather and are followed by clouds and storms, are commonly preceded by a strong ascending air current. This law is confirmed by the experience of K. von Bassus in an ascension made at Munich in June, 1907. The ascension was made late in the afternoon, under an apparently clear sky, but when the aeronaut had risen a short distance he perceived a storm cloud in the west and another in the south. About 8 o'clock it began to thunder and the clouds drew nearer together. A quarter of an hour later the balloon, which had attained an elevation of 730 meters (2,400 feet) shot upward so rapidly that in a few minutes it had risen to a height of 1,420 meters (4,660 feet) although the escape valve was kept open. The velocity of ascent exceeded 100 meters (328 feet) per minute. The registering instruments were of excellent make, and were tested and found correct before and after the ascension, so that there can be no doubt of the facts recorded by them.

That radioactivity plays a part in the production of the earth's internal heat was emphasized once more by Prof. John Joly in his presidential address before the Section on Geology of the British Association for the Advancement of Science. He propounds the theory that uranium (the parent of radium) is the source of the earth's heat and that the upheaval of the earth's crust, with the consequent formation of mountain chains, is due to radio-thermal action. His complete paper will be published in the columns of the SCIENTIFIC AMERICAN SUPPLEMENT. Because the radioactive minerals suffer decay, it must follow, if this theory is correct, that the earth's heat will some day be entirely dissipated. The accumulation of earths penetrated with uranium increases in temperature as the square of the depth, expanding the crust as the heat rises by a stress that ultimately finds relief in a flexure and ridge of mountains. The continents themselves rise from the ocean bed, only to be submerged again when enough radio-active sediment is washed back into the ocean beds to cause a second upheaval and displacement of the oceans. It is estimated that the dark, unfathomed caves of the ocean are overspread with twenty million cubic miles of matter once in solution, the quantity of radium involved being "considerably over a million tons."

As an interesting example of the working of the true mathematical mind, the case of Prof. Akerlund, of the Boras Technical College, Sweden, who lately died, may be mentioned. In many particulars this man resembled Lord Kelvin, and he was well known in mathematical circles in Scandinavia. His former instructor in mathematics stated that, while at high school, after the first principles and the object of trigonometry and analytical geometry had been verbally explained to him, he worked out and became proficient in the fundamental theories of these two subjects without the aid of any text-books whatever. While at the university he studied philosophy, but as a true mathematician he would accept nothing which he did not understand, and as he found that the learned text-book in logic used there was beyond his own comprehension, he would not admit that it was founded on real logic, and finally made the professor of the subject himself admit that he, too, did not comprehend the particular subject as taught. This is the supreme test of the true mathematician. He accepts nothing as fact unless he can comprehend or prove it. In this connection it may be interesting to note that Akerlund, while still at school, constructed an electric motor simultaneously with Gramme. Gramme, however, brought his invention first before the public eye and consequently the credit of being the inventor of the electric motor has been accredited to him.—Machinery.

ENGINEERING NOTES.

Superheated steam locomotives appear to be so favorably considered by European railroads that at the present time hardly any express locomotives are ordered without superheaters. Recently 24 express locomotives for the Italian State Railways, built in Germany, were completed, all being furnished with Schmidt superheaters.

The British Admiralty has decided that in the future all small naval craft shall be constructed to use both coal and oil fuel. The oil-burning system has been used for a considerable time, and many of the destroyers and torpedo boats are designed exclusively for the oil-burning system. All the modern battleships and cruisers of the navy are also constructed to use either coal or oil.

The Society of German Engineers at its annual convention held in Dresden empowered its officers to negotiate with representatives of the Prussian State government, as well as the government of the German Federation, to make arrangements for the bringing out of the Technolexikon, which the society was forced to give up about a year ago, on account of the great scope of the work, involving expenditures greater than the society considered that it could consistently make.

Washing tests on coal made by the St. Louis laboratory of the United States Geological Survey show an increase in moisture of 10 to 30 per cent, a reduction in ash in the 1905 tests of 15 to 50 per cent, and in the 1906 tests of 20 to 60 per cent, and a reduction in sulphur in the 1905 tests of 10 to 40 per cent, and in the 1906 tests of 10 to 50 per cent. A raw coal containing 5.05 per cent of sulphur had 2.47 per cent after washing, a removal of 55 per cent. The ash in a raw coal containing 42.56 per cent was reduced by washing to 29.67 per cent, a total removal of 65 per cent, and in another case from 15.72 to 10.16 per cent. A bulletin has been issued by the Survey giving details of the tests.

In view of the present agitation for the preservation of the natural resources of the United States, the methods employed by the Swedish government for the preservation of forest reserves as well as ore deposits are of special interest, and we have previously referred to the replanting of forests, the limitation of export shipments of iron ore, and the taking over of some iron ore deposits by the government. It is now reported that the Swedish government is still further pursuing the policy of actual ownership of ore deposits, the present parliament having passed a bill providing for the state purchase of the important Svappavaara ore fields in the northern part of the country.

A White Paper just issued gives comparative tables of the strength of the fleets of Great Britain, France, Russia, Germany, Italy, the United States, and Japan on March 31, 1908, including ships of all classes built and being built on July 3 last year, when the Dilke return was issued. Taking the return as it stands, says the Standard, including all warships in existence irrespective of their condition and their fighting value, we find that in battleships the British fleet is below the two-power standard. The accepted definition of that standard is that the British fleet should be equal in battleships to the fleets of any two foreign powers combined, with an addition of 10 per cent. The journal prints the following figures: Battleships built: Great Britain, 59, total, 59; Germany, 34; United States, 25; total, 59. Battleships being built: Great Britain, 8, total, 8; Germany, 9; United States, 5; total, 14.

The compressive strength of concrete and mortar, as influenced by the proportion of water, was investigated recently by Herr Brabandt, a German railway engineer, the conclusions being published in the Centralblatt der Bauverwaltung. The test cubes were 30 centimeters—about 12 inches—on a side, and were made in accordance with the rules of the Deutsche Betonverein. They were stored in a shed under wet sand, and were tested after twenty-eight days. The test results showed a certain proportion of water which gave the greatest strength, either more or less water giving poorer results. The conclusions drawn by Herr Brabandt from his tests on concrete are as follows: (1) The most favorable quantity of water for the mixtures commonly used is about 15 to 20 per cent of the volumes of cement and sand. (2) Poor mixtures need less, rich ones more water. (3) The moisture already contained in the raw materials must always be considered. (4) The absorption of water by the gravel, ballast, or broken stone must be taken into consideration. The quantity of water thus required must be determined beforehand by tests, and added to the quantity needed for the mortar. (5) In cold seasons less water, in warm weather more water must be used. (6) With very rich mortar mixtures, with more cement than sand, the amount of water demanded is considerable, and may even reach 30 per cent. (7) It seems wise to determine the amount of water by tests, at least when required for large buildings, and to regulate it by general specifications.

TRADE NOTES AND FORMULÆ.

Water-proof paint for wagon covers may be made by dissolving 50 parts of gelatine in 75 parts of glycerine and 150 parts of water and adding 0.5 part of salicylic acid dissolved in alcohol. The mass must be heated before use and 15 parts of chromate of potassium added to it.

Arsenical Soap for the Protection of Animals.—4 parts of tallow soap dried and pulverized, 10 parts of water, 1 part unslaked lime, 2 parts of potash, 4 parts arsenic, 1 part camphor, all to be rubbed down in a mortar to a salve. This soap, with which skin and bone parts are anointed, insures, according to experience, the most certain protection but must be used with care.

For Removing Rust.—Quartz sand, finely ground, 20 parts; ground pumice, 10 parts; tripoli, 30 parts; paraffine, 5 parts; light mineral oil, 0.900/5, 35 parts. The paraffine and mineral oil are melted together and the pulverized materials stirred into it. Heat it until it is uniformly fluid, then pour it out into boxes. If it is desired to give it a lighter color, add a little zinc white; if a yellow color is preferred, a little chrome yellow; if red, some English red.—Chim. Techn. Fabrikant.

To Bleach Bath Sponges.—This is usually effected with the aid of potassium bichromate. As a small quantity of chromate in a sponge, used cosmetically and in surgery, might prove serious, Gawalowsky recommends bleaching by immersion in 10 per cent solution of bisulphite of calcium. First the carefully cleansed sponges are placed in warm dilute soda lye, allowed to remain there for a time, then washed out well with water and then with dilute sulphuric acid (1:6H_2O) until no more effervescence is produced. Finally, take the sponges out and wash them carefully in water until it runs clear from them.

Arsenical soap is used as an antiseptic medium and a protection against insect depredations, and is also employed for application to the fleshy side of animal skins which are intended for stuffing. According to a recipe of Becours, it is made as follows: To a solution of 100 parts of soap, in water, add 36 parts of potash and 12 parts of slaked lime, then add 100 parts of pulverized arsenious acid, transform the mass by heating into a uniform paste and finally mix in 15 parts of pulverized camphor. According to a French recipe, the soap used for coating animal skins must be prepared as follows: 320 parts of arsenious acid, pulverized, 320 parts of distilled water, and 120 parts of dry potash are heated in a porcelain dish until complete solution of the arsenious acid is obtained; then add 320 parts of cut-up Marseilles soap and stir until a paste is produced, to which, after cooling, 40 parts of pulverized caustic lime and 10 parts of pulverized camphor are added. According to Klener, we obtain a mass adapted for similar purposes if we stir 1 part of arsenious acid and 8 parts of powdered gypsum with wood-ash lye and some pipe clay.

Artificial Asphalt.—I. According to Valenta, if ordinary rosin is melted and to the melted rosin sulphur is added, it will be dissolved, forming a clear mass. On heating this mixture in a crucible to 482 deg. F. (250 deg. C.) there will be obtained an almost black, sulphurous, pitchy resin, the properties of which closely resemble those of the Syrian asphalt. It does not dissolve in alcohol, but is readily dissolved in chloroform and benzole. The benzole solution is of brown color, and applied in a thin coat to glass leaves, on drying, a solid coat of varnish, which displays remarkable sensitiveness to light, about to the same extent as Syrian asphalt, which, in photography, is employed for heliographic metal etchings. II. Crude petroleum or its residue is exposed to the effects of steam, to remove the paraffine it contains, and then heated to a sufficient degree to completely expel any moisture present. To the raw material thus treated, sulphur is added in definite proportions, after which the mixture is kept at a temperature just below the distillation point, until the desired combination is attained.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—The Voisin Aeroplane Factory.—1 illustration... 250

II. BIOLOGY.—The Movements of Plants.—III.—By FRANCIS DARWIN, M.A., Ph.D., LL.D., F.R.S.... 250

III. ELECTRICITY.—The Tantalum Detector for Wireless Signaling 250
The Present Status of the Flaming Arc Lamp.—By ALFRED A. WOHLAUER.—14 illustrations.... 250

IV. ENGINEERING.—Pneumatic Caissons.—I.—By T. KENNARD THOMSON.—8 illustrations.... 252
The Power Measurement of Engines.... 252
The Carnot Cycle. What it is.... 252
Engineering Notes.... 253

V. GEOLOGY.—Prof. See's Farther Researches on the Physics of the Earth.... 251

VI. HYGIENE AND MEDICINE.—Industrial Dust and Disease.... 253

VII. MISCELLANEOUS.—Septic Tank Experience at Stratford-on-Avon.... 253
The Development of Invention.... 253
The Conservation of Resources.... 253
Science Notes.... 253
Trade Notes and Formulæ.... 253

VIII. TECHNOLOGY.—German Kieselguhr.... 255
Some Curious Old Bottles.—By THOMAS OXLEY.—6 illustrations.... 255

IX. ZOOLOGY.—Our American Flycatchers.—By B. S. BOWDISH.—7 illustrations.... 255